Town Branch Watershed Management Plan

January 2012

Bolivar Community Watershed Improvement Group

MISSOURI DEPARTMENT OF NATURAL RESOURCES

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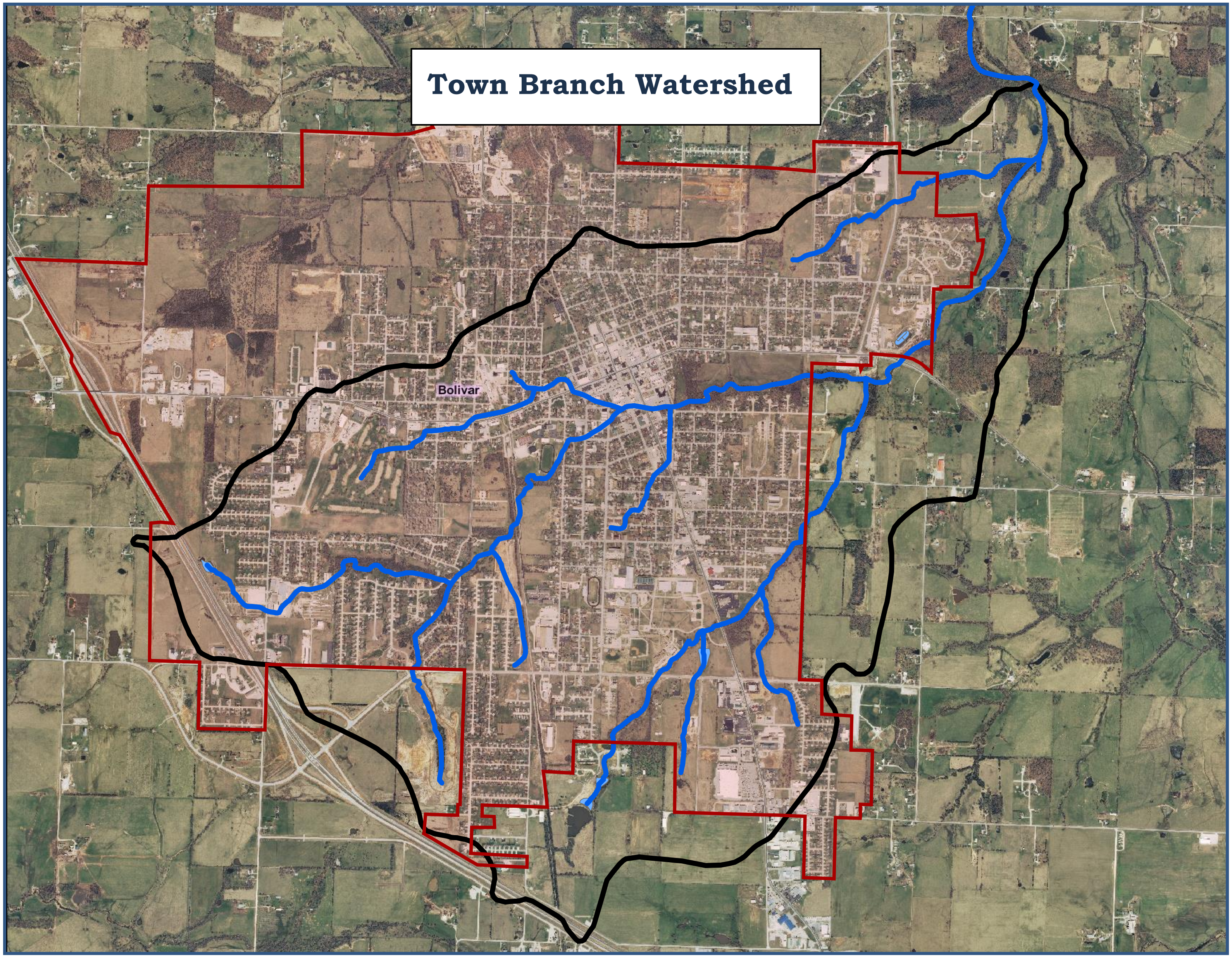
Town Branch Watershed
Bolivar

Bolivar Community Watershed Improvement Group

Town Branch Watershed Management Plan

Mission Statement

To create a comprehensive and strategic watershed plan in order to serve as a guide to improve and sustain the water quality resources of Town Branch and Piper Creek.

Community Project sponsored by BCWIG

Educational Booth Display

Partners

Bolivar Community Watershed Improvement Group

Missouri Department of Natural Resources

USDA NRCS United States Department of Agriculture Natural Resources Conservation Service

City of Bolivar

Polk County Commission

Live Well Polk County Health Center

University of Missouri Extension

Acknowledgements

Planning, design and implementation of the Town Branch Watershed Management Plan would not have been possible without the participation of the Bolivar Community Watershed Improvement Group (BCWIG) and its valued supporters and partners. Through their vision and diligence, this plan will be a valuable resource for current and future watershed protection efforts. Such noted supporters and partners include the City of Bolivar, Polk County Commission, Polk County Health Department and the Natural Resources Conservation Service.

Special appreciation is given to Delbert Simpson, past chairman of BCWIG who facilitated the organization of this group as well as providing the leadership in attaining the planning grant to write this watershed management plan. Appreciation and remembrance is also given to the late Anne Peery of Missouri Department of Natural Resources-Water Pollution Control Program who assisted BCWIG in its formation and who was instrumental in guiding BCWIG throughout the TMDL process. We would also like to recognize John Johnson, nonpoint project officer of the Missouri Department of Natural Resources-Water Pollution Control Program whose guidance, oversight and patience in this process is greatly appreciated.

We would also like to thank Bob Broz and Dan Downing of the University of Missouri Extension-Water Quality Program for assisting BCWIG throughout this watershed planning process. Special gratitude is also given to Drury University-Environmental Programs for assisting BCWIG in the assessment phase of this plan.

We acknowledge the persistence, dedication and valuable work of the individuals listed in the Introduction section of this document. They represent the foundation on which this plan was built. Finally we would like to thank Sam Kirby of BCWIG whose organization and management skills have kept its members and cooperators informed and committed to the mission of BCWIG as well as Adam Coulter, NRCS Urban Conservationist/Geographer-South Missouri Water Quality Project, whose extraordinary abilities with plan development, input coordination and unique resource knowledge have been invaluable in the creation of this plan.

BCWIG Volunteers

Bolivar Community Watershed Improvement Group

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Executive Summary

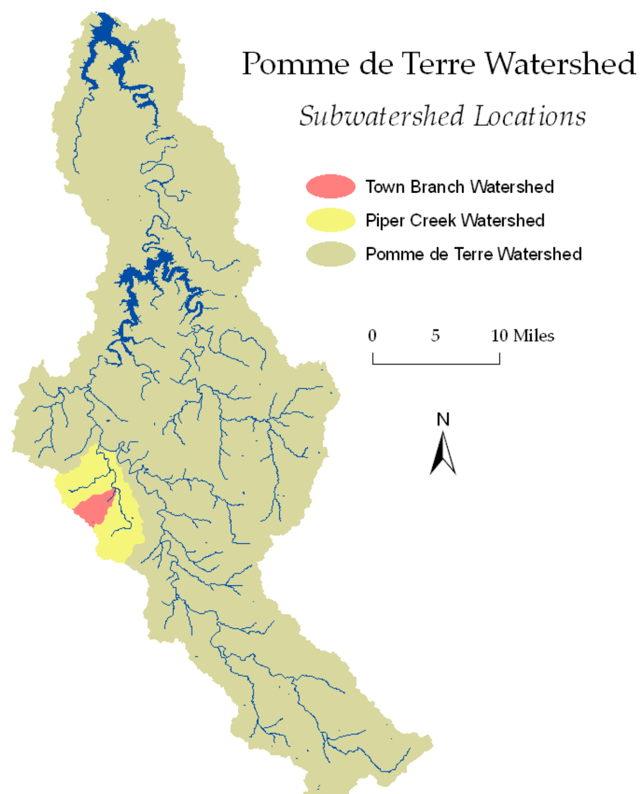
Background

The Bolivar Community Watershed Improvement Group (BCWIG) is a local non-profit organization made up of local residents representing a broad section of this community. This non-regulatory and voluntary organization was formed in 2005 to address the water quality issues impacting Bolivar and its surrounding areas. The purpose of BCWIG is to restore and enhance water quality conditions of the Town Branch watershed in order to improve and sustain the quality of life for the Bolivar and Polk County area. BCWIG implements its goals through water quality monitoring, educational and restoration activities.

In 2008, BCWIG received a Clean Water Act, Section 319 watershed management planning grant from the Missouri Department of Natural Resources through the United States Environmental Protection Agency-Region VII. The purpose of this grant (and subsequent report) is to assess water quality impairment sources in the Town Branch watershed and to develop a comprehensive plan to address, reduce and deter further impairment. The Town Branch watershed is a tributary of Piper Creek which is designated as an impaired waterbody by the EPA through the Clean Water Act, Section 303(d) for waterways not meeting water quality standards. Because of this, a Total Maximum Daily Load (TMDL) was established by United States Environmental Protection Agency in order to determine a level necessary to achieve applicable water quality standards. This TMDL process will be incorporated into the Town Branch watershed management plan.

Watershed Location and Land Use

The Town Branch watershed is predominately located within the city limits of Bolivar Missouri. Encompassing over 3,800 acres, this waterbody drains into the Piper Creek watershed of the larger Pomme de Terre River watershed. Positioned as the seat of Polk County, Bolivar is the economic, educational and cultural center of this county and nearby region. In 2010, Bolivar's population of 10,325 increased at a 12.93% rate over the past ten years. New development and industry is increasing due to the high quality of life this region offers. The Town Branch watershed is predominately an urban watershed with 67.6% being identified as urban land cover. Thus, the majority of watershed protection efforts will be focused on urban watershed non-point sources such as impervious areas, existing septic systems, degraded stream corridors and new development.



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Water Quality Pollutants

The pollutants of concern that will be addressed through this watershed management plan include: Total Nitrogen, Total Phosphorous and Total Suspended Solids.

Definition and Impacts

Total Phosphorous: Phosphorus is an essential element for life. It occurs in various forms-either as dissolved (inorganic) or particulate (organic) forms. Dissolved phosphorus is more readily available for uptake by aquatic plants such as algae. Examples of particulate forms include phosphorus locked up in plant residue, manure or soil. These forms are generally released over time through decomposition or agitation and thus are converted over into dissolved phosphorus. Elevated levels of phosphorous (and nitrogen) can greatly impair streams through the proliferation of algal blooms. Since phosphorous is a major source for plant growth, elevated levels can increase unwanted algal growth in streams. When alga dies, microbes will decompose the plant material. In this process, dissolved oxygen levels become depleted. These lower oxygen levels can facilitate fish kills and impair other aquatic organisms.

Total Nitrogen: Nitrogen is another nutrient that is essential for life. Much like phosphorus, nitrogen occurs as dissolved (inorganic) or particulate (organic) forms. Nitrogen occurs in natural waters in various forms, including nitrate (NO_3), nitrite (NO_2), and ammonia (NH_3). Nitrogen-containing compounds act as nutrients in streams and rivers. Nitrate reactions in fresh water can cause oxygen depletion. Thus, aquatic organisms depending on the supply of oxygen in the stream will die. The major routes of entry of nitrogen into bodies of water are municipal and industrial wastewater, septic tanks, feed lot discharges, wild animal wastes and discharges from car exhausts.

Total Suspended Solids: Total suspended sediment is a qualitative indicator for measuring sediment loading in rivers and streams. Sediments can cause dissolved oxygen levels in streams to fluctuate while smothering aquatic invertebrates thus impairing biotic life. Sources of excessive sediment occur from decaying matter, waste water effluent, as well as agricultural and urban runoff.

Pollutant	Sources	
Phosphorous	Urban:	Over fertilization of residential yards, pet waste, land disturbance with improper sediment and erosion control methods, failing septic systems, streambank erosion.
	Agricultural	Improper livestock and manure management, streambank erosion
Nitrogen	Urban	Over fertilization of residential yards, pet waste, land disturbance with improper sediment and erosion control methods, failing septic systems, streambank erosion.
	Agricultural:	Improper livestock and manure management, streambank erosion.
Sediment	Urban:	Poor riparian management, streambank erosion, improper sediment/erosion control, transportation deposition
	Agricultural:	Over grazing, poor riparian management and streambank erosion.

Piper Creek/Town Branch TMDL

Piper Creek is listed on the Missouri Department of Resources 303(d) List for Impaired Waterbodies due to high levels of organic sediment. Section 303(d) of the federal Clean Water Act requires that each state identify waters that are not meeting water quality standards and for which adequate water pollution controls have not been required.

The area of impairment in this watershed begins on the southern Town Branch section starting from Springfield Avenue and flowing into Piper Creek. This impairment continues for the duration of Piper Creek (approximately 7.5 miles) until its confluence with the main stem of the Pomme de Terre River. In order to address the sources of impairment, a Total Maximum Daily Load (TMDL) was calculated. A TMDL is a term in the Clean Water Act, describing a value of the maximum amount of a pollutant that a body of water can contain while still meeting water quality standards. Alternatively, TMDL is an allocation of that water pollutant deemed acceptable to the subject receiving waters.

From the information generated through assessment, monitoring and modeling techniques, the identified source of impairment is listed as the City of Bolivar Waste Water Treatment Facility and other unknown sources. Evidence supports that the other unknown sources are emanating from non-point sources. The pollutants identified and subsequently addressed in the TMDL are nutrients (total phosphorus and total nitrogen), sediment (total suspended sediment), and low dissolved oxygen. ***The purpose of this watershed management plan is to identify and address non-point sources.*** Non-point sources include generalized contributors of pollutants that emanate from non-discernible sources that are difficult to measure. Such areas include runoff from agriculture and urban areas, on-site wastewater systems and degraded channel and riparian conditions such as stream bank erosion. Due to the size and complexity of these sources, they are typically not regulated but are addressed through education, the implementation of local standards and cost-share assistance.

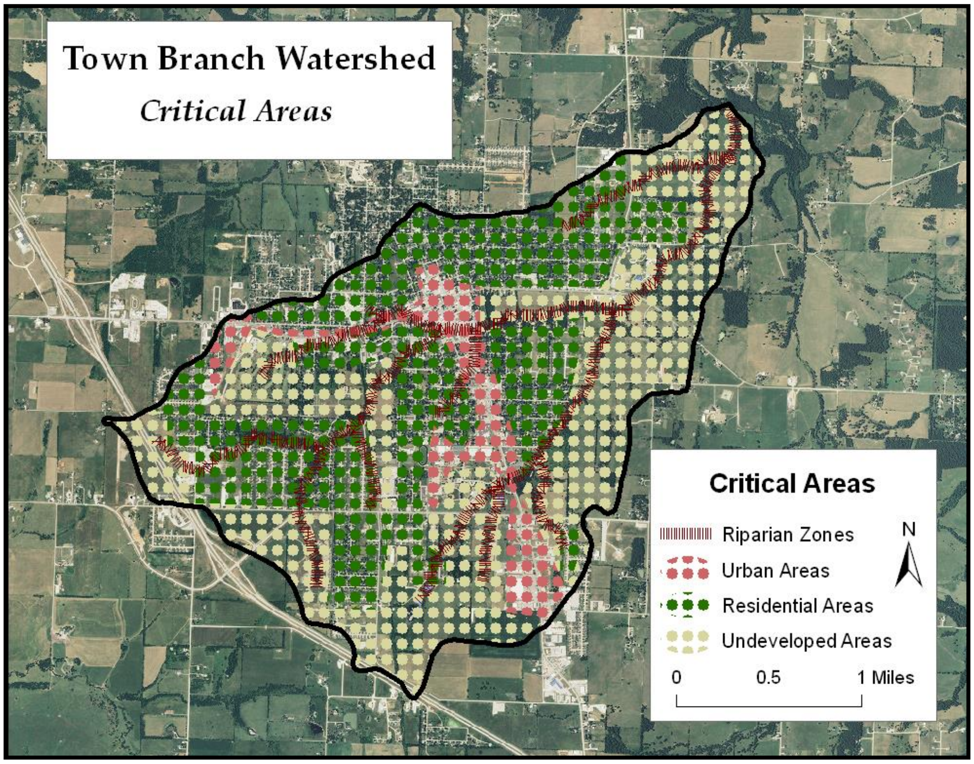
In 2010, a Total Maximum Daily Load (TMDL) was established for non-point sources in the Town Branch watershed by the United States Environmental Protection Agency in order to determine a level necessary to implement applicable water quality standards. The following information summarizes the established TMDL for Town Branch and Piper Creek:

Pollutant	Current Load*	TMDL**	Reduction
Total Nitrogen	1.1 lbs/day	0.1 lbs/day	1.0 lbs/day (91%)
Total Phosphorus	0.02 lbs/day	0.003 lbs/day	0.017 lbs/day (85%)
Total Suspended Solids	No applicable data	3.0 lbs/day	Not applicable

* As calculated by montioring
** The amount needed to reach water quality standards

Critical Pollutant Areas

In order to address the pollution concerns as stipulated in the TMDL, the Town Branch watershed was assessed through various methods in order to determine critical areas of concern and pollutant contribution. Based upon on-site assessments, water quality data and land use patterns; a critical pollutant map was created to prioritize areas of concern.



It is important to note that the areas identified can be addressed by implementing various structural and non-structural BMPs. The map displays areas where generalized BMPs can be implemented. In the following sections, a more detailed analysis of specific BMP stratgies and milestones will be provided that will help to reduce the loading of water quality pollutants. The areas identified as critical are further analyzed for pollutant contribution in the following sections as well.

Poorly Vegetated Riparian Corridor

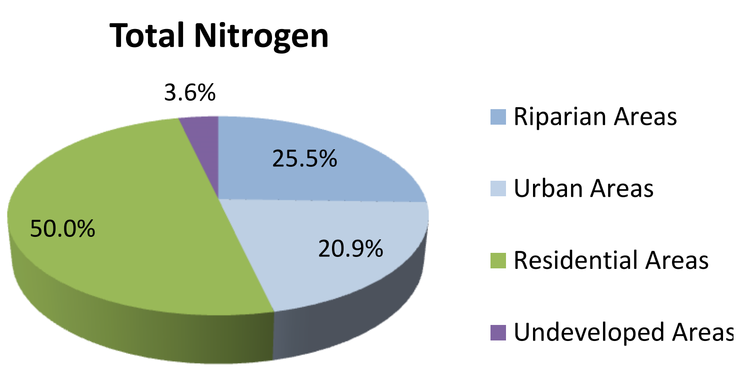
Construction Site Runoff

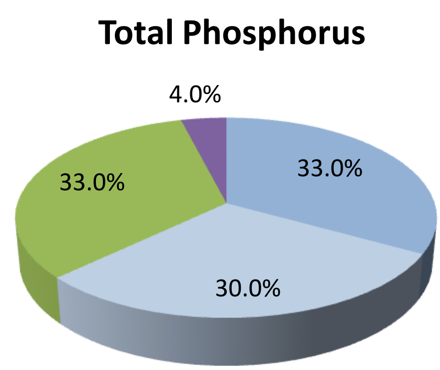
Critical Pollutant Contributions

The following table summarizes and describes the pollutant influence of the identified critical areas. The pollutant loads and contributions were calculated based on the STEPL model as well as incorporating water quality data, land uses and area.

Critical Area	Description/Issues	Pollutant Load	Percent of Contribution
Riparian	Areas along the riparian corridor where cuts banks, active streambank erosion, poor buffer width and lack of vegetative diversity contribute to total suspended solids, phosphorus and nitrogen loads.	TN=.28 lbs/day TP= 0.0066 lbs/day	TN= 25.5% TP = 33.0%
Urban	Areas of concentrated and connected impervious structures such as buildings, parking lots and roads that contribute to total suspended solids, phosphorus, nitrogen, heavy metal, and volatile organic compound loads.	TN=.23 lbs/day TP= 0.0060 lbs/day	TN= 20.9% TP = 30.0%
Residential	Areas of residential developments where lawn fertilizers, pet waste and waste water systems are present and contribute to phosphorous, nitrogen and bacteria loads.	TN=.55 lbs/day TP= 0.0066 lbs/day	TN= 50.0% TP = 33.0%
Undeveloped	These areas are undeveloped parcels which contribute minimal pollutant loads. These are areas that are anticipated to become developed as residential, commercial or industrial ventures.	TN= 0.04 lbs/day TP= 0.0008 lbs/day	TN= 3.6% TP = 4.0%
Total	The following totals for pollutant load should equal the current baseline load as calculated in the TMDL.	TN= 1.1 lbs/day TP= 0.02 lbs/day	TN= 100% TP = 100%

The following chart visually displays the contribution of land uses to water quality impairment in the Town Branch watershed.





Load Reduction Strategies

In order to address and achieve the load reductions calculated in the before mentioned TMDL, certain management measures will have to be implemented over time. These management measures include implementing best management practices as well as developing an outreach and monitoring strategy.

Best Management Practices

Best management practices (BMPs) are structural and non-structural components and procedures that can be implemented throughout a watershed to deter the impacts from non-point source pollution. In order to enhance and preserve the current water quality conditions of the Town Branch watershed, BMPs need to become general knowledge and applied through education, voluntary adoption and technical oversight.

Structural BMPs

Structural BMPs include practices that are implemented on the land such as the construction of storm water controls (forebay-detention basins, grassed swales, bioretention cells, rain gardens, etc.), establishing riparian corridors/buffers and the utilization of advancing technological systems (water/oil separators, permeable pavement, centrifugal sediment separators, etc.).

Non-Structural BMPs

Non-structural BMPs focus on non-physical practices such as education, planning, zoning and community development. These methods are typically less costly than structural practices. Examples include ordinances designed to preserve open space or create stream buffer setbacks as well as cost-share programs that help landowners implement structural BMPs.

Newly Constructed Bioswale

Sediment and Erosion Control

Parking Lot Bioretention Cell

Low Impact Landscaping

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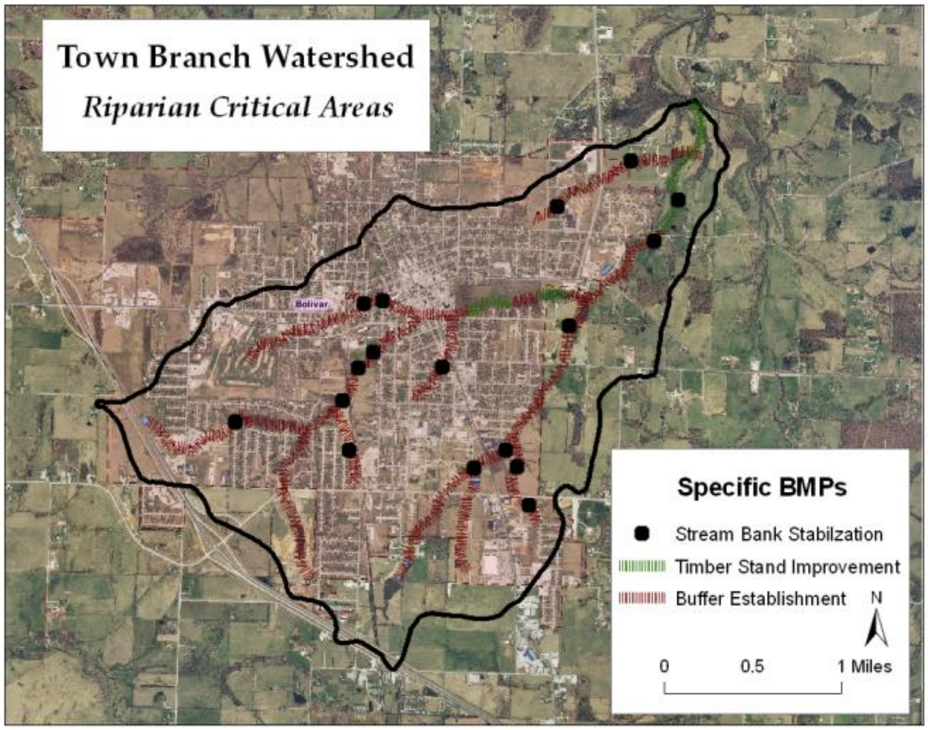
Structural BMPs-Riparian Areas

As previously stated, certain riparian areas have been identified that contribute to pollutant loading. The following map identifies areas where certain BMPs can be implemented.

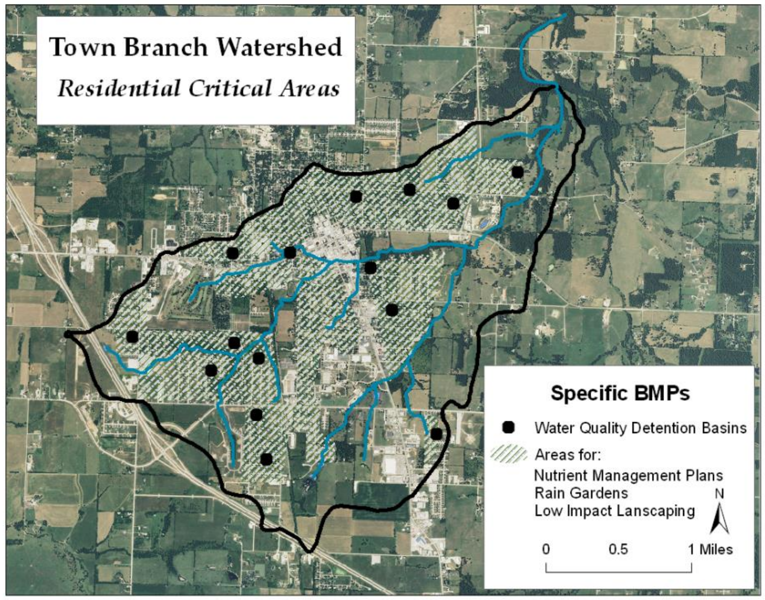


The following strategic BMPs will help to deter pollutant loads emanating from these areas. The amount of pollutant reduction is based on various BMP databases and indicators. A more detailed description of these practices can be found in Appendix B in the main document.

BMP	Description	Percent Reduction		
		TN	TP	TSS
Stream Bank Stabilization	Fortifying cut banks on stream reaches or meanders where active erosion is taking place. Such BMPs include hard armoring and natural vegetation techniques.	65%	70%	90%
Buffer Establishment	Establishing and enhancing the width of the riparian buffer helps to filter runoff pollutants, deters stream bank erosion and provides wildlife habitat. A fifty-foot buffer is the optimal width for reducing pollutants.	65%	75%	90%
Timber Stand Improvement	The purpose of this practice is to remove diseased and weak trees in order to facilitate a proper forest succession and diversity. It also facilitates healthy canopy and root system growth that helps deter erosion.	Undetermined		

Structural BMPs-Residential Areas

As previously stated, residential areas have been identified that contribute to pollutant loading. The following map identifies areas where certain BMPs can be implemented.

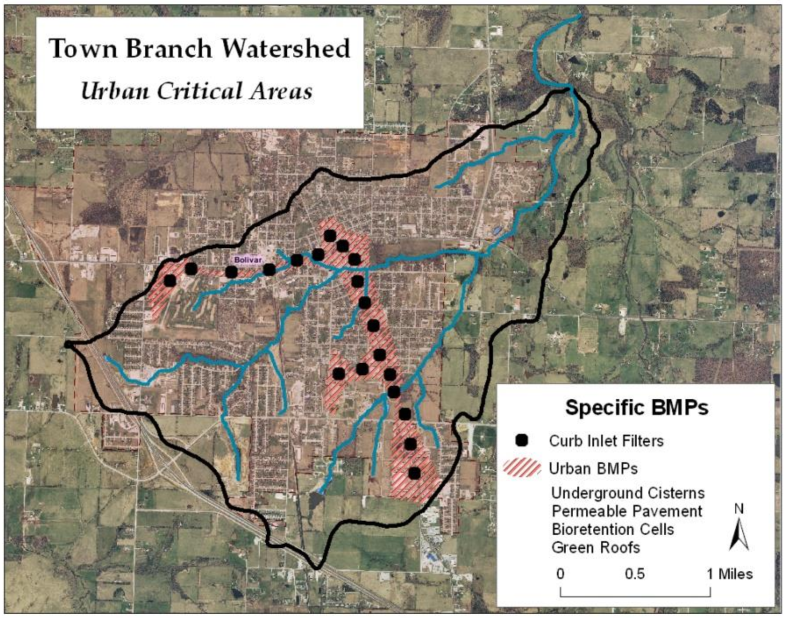


The following strategic BMPs will help to deter pollutant loads emanating from these areas. The amount of pollutant reduction is based on various BMP databases and indicators. A more detailed description of these practices can be found in Appendix B of the main document.

BMP	Description	Percent Reduction		
		TN	TP	TSS
Water Quality Detention Basins	Retrofitting existing detention basins and erecting new detention basins (above minimal requirements) will help to deter pollutant loads.	75%	80%	90%
Nutrient Management Plans	The purpose of this practice is to prescribe an actual fertilization plan that will meet optimal soil fertility conditions. This will require soil tests, lawn measurements and an inventory of over the counter fertilizers.	95%	95%	n/a
Rain Gardens	Rain gardens are small depressional areas used to filter out storm water runoff pollutants. These gardens provide aesthetic benefits and can be sited in residential and commercial lots.	75%	85%	90%
Low Impact Landscaping	Low impact landscaping incorporates numerous practices such as rain barrels, native landscaping and border gardens that decrease the amount of lawn space and runoff on an individual lot.	75%	80%	90%

Strucutural BMPs-Urban Areas

As previously stated, urban areas have been identified that contribute to pollutant loading. The following map identifies areas where certain BMPs can be implemented.

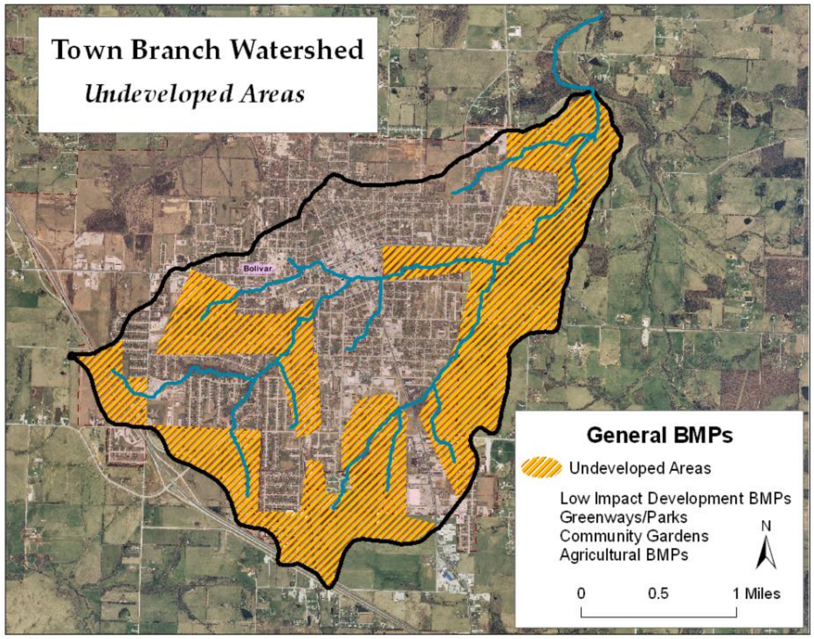


The following strategic BMPs will help to deter pollutant loads emanating from these areas. The amount of pollutant reduction is based on various BMP databases and indicators. A more detailed description of these practices can be found in Appendix B of the main document.

BMP	Description	Percent Reduction		
		TN	TP	TSS
Curb Inlet Filters	These are devices that can be inserted into storm water inlet drains that will filter out pollutants such as oils, greases, sediment and nutrients attached to such substances.	75%	80%	90%
Storage Cisterns Rain Barrels	Underground cisterns and rain barrels can be placed to collect storm water runoff from roof tops in order to be used for non-potable purposes such as watering municipal facilities.	Not Estimated		
Permeable Pavement	Permeable pavements allows for storm water runoff to infiltrate into the pavement material thus deterring runoff and filtering pollutants.	65%	75%	90%
Bioretention Cells	Bioretention cells are similar to rain gardens but are designed to handle larger amounts of runoff from areas such as parking lots and commercial developments.	75%	85%	90%
Green Roofs	Green roofs are vegetated areas grown on top of buildings and other impervious structures that capture and absorb rainfall.	80%	90%	50%

Strucutral BMPs-Undeveloped Areas

The following map displays areas of undeveloped land. It can be assumed that these areas will be developed for residential or commercial uses in the future. However, if low impact development practices can be implemented, then that would lessen the impacts these future land uses will have upon water quality.



The following is a general description of the various practices and land uses that could be employed if land is eventually developed.

BMP	Description
Low Impact Development Practices	This method incorporates different practices such as bioswales, rain gardens, bioretention cells, pervious pavements into innovative development designs for new residential and commercial developments.
Greenways/Parks	The purpose of this practice is to remove diseased and weak trees in order to facilitate a proper forest succession and diversity. It also facilitates healthy canopy and root system growth that helps deter erosion.
Community Gardens	Establishing and enhancing the width of the riparian buffer helps to filter runoff pollutants, deters stream bank erosion and provides wildlife habitat. A fifty-foot buffer is the optimal width for reducing pollutants.
Agricultural BMPs	The only agricultural land use in the Town Branch watershed is undeveloped land used for haying. If more intensive agricultural operations are employed in the future than practices such as rotational grazing, alternative watering and pasture enhancement/management.

Municipal Structural and Non-Structural BMPs

In 2010, Bolivar's population exceeded 10,000 residents. Because of this, the City of Bolivar will be complying with the NPDES Phase II requirements to address storm water runoff. Though it can be expected that this will be a long term process; the following chart outlines specific areas that will have to be addressed.

Program	Purpose	Specifics
Public Education & Outreach	To make the public aware of stormwater and its impacts.	• Implement a public education program for the community regarding stormwater runoff. • Targeting local business regarding impacts and practices to deter such impacts.
Public Participation & Involvement	To involve the community in voluntary result-oriented activities.	• Facilitate public meetings for citizen input and comments regarding stormwater. • Facilitate citizen groups in community based projects.
Illicit Discharge Detection & Elimination	To identify stormwater sources and standardize proactive actions.	• Develop a storm sewer system map. • Develop a storm water ordinance. • Enlighten public employees, business and citizens on disposal practices.
Construction Site Storm Water Runoff Control	To address non-point sources from construction sites and minimize pollutant loads	• Develop a comprehensive sediment and erosion control ordinance. • Facilitate educational seminars for developers, contractors and engineers.
Pollution Prevention & Good Housekeeping	To demonstrate municipal involvement and compliance	• Implement programs for municipal-based operations (street sweeping, recycling, etc.) • Provide employee training.

This process will be integral in implementing the watershed management plan for Town Branch since its land uses are predominately urban and residential. It will important to note that the specificities (such as financing, ordinances, staff resources) of this program have not yet been developed. However, when this process becomes operation, it will surely have a significant impact on reducing non-point sources of pollution. More detailed information regarding the NPDES Phase II process can be found in Appendix B of the main document.

Load Reduction Milestones

Based upon the best management practices that could be employed in each critical area, a plan for reducing pollutant loads can be estimated in order to achieve water quality standards. The following tables display the reduction loads for specific practices over a reasonable period of time. Calculations were based on the STEPL method and BMP calculator.

Riparian BMPs

BMP	1-3 Years		4-7 Years		8-10 Years	
	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)
Stream Bank Stabilization	7 sites	TN=0.081 TP=0.001	10 sites	TN=0.115 TP=0.002	10 sites	TN=0.115 TP=0.002
Buffer Establishment	11,600 ft.	TN=0.017 TP=0.0006	29,000 ft.	TN=0.042 TP=0.0012	17,400 ft.	TN=0.025 TP=0.0009

Residential BMPs

BMP	1-3 Years		4-7 Years		8-10 Years	
	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)
Water Quality Detention Basins	4 sites	TN=0.063 TP=0.000754	5 sites	TN=0.079 TP=0.000943	5 sites	TN=0.079 TP=0.000943
Nutrient Management Plans	50 sites	TN=0.0231 TP=0.000283	100 sites	TN=0.0462 TP=0.000565	200 sites	TN=0.0924 TP=0.001131
Rain Gardens	10 sites	TN=0.022 TP=0.000264	20 sites	TN=0.044 TP=0.000528	20 sites	TN=0.044 TP=0.000528
Low Impact Landscaping	10 sites	TN=0.011 TP=0.00013	20 sites	TN=0.022 TP=0.000264	20 sites	TN=0.022 TP=0.000264

Urban BMPs

BMP	1-3 Years		4-7 Years		8-10 Years	
	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)
Curb Inlet Filters	5 sites	TN=0.00575 TP=0.00015	10 sites	TN=0.0115 TP=0.0003	5 sites	TN=0.00575 TP=0.00015
Permeable Pavement	.5 acres	TN=0.0138 TP=0.00036	1 acre	TN=0.0276 TP=0.00072	2 acres	TN=0.0552 TP=0.00144
Bioretention Cells	5 sites	TN=0.023 TP=0.0006	10 sites	TN=0.046 TP=0.0012	10 sites	TN=0.046 TP=0.0012
Green Roofs	1 site	TN=0.0038 TP=0.0001	2 sites	TN=0.0077 TP=0.0002	3 sites	TN=0.0114 TP=0.0003

Undeveloped Area BMPs

The following chart projects practices that could be implemented over time for undeveloped areas of land and municipal purposes such as a storm water management program. Load reductions are not calculated due to unknown factors such as acreage and land use type. However, the number of projects and type of practices are estimated in order to give planners an economic estimate which will be provided in the following section.

BMP	1-3 Years		4-7 Years		8-10 Years	
	Number	Practices	Number	Practices	Number	Practices
LID Practices	5 sites	Bio swales Bioretention Xeriscaping, etc.	5 sites	Bio swales Bioretention Xeriscaping, etc.	5 sites	Bio swales Bioretention Xeriscaping, etc.
Greenways Parks	5 acres	Land acquisition Trail Building Maintenance	10 acres	Land acquisition Trail Building Maintenance	15 acres	Land acquisition Trail Building Maintenance
Community Gardens	1 sites	Land acquisition Structural BMPs	1 sites	Land acquisition Structural BMPs	1 sites	Land acquisition Structural BMPs
Agricultural BMPs	2 sites	Pasture/Grazing Management	2 sites	Pasture/Grazing Management	2 sites	Pasture/Grazing Management

Load Reduction Strategies

Outreach Program & Strategy

Education and outreach activities are designed to inform the public on BMPs and conditions that relate directly to improvement of water quality within the watershed. Many avenues for outreach are available to residents of the watershed. Organizations such as the Environmental Protection Agency, Natural Resources Conservation Service, Soil and Water Districts, Missouri Department of Conservation, University of Missouri Extension, City of Bolivar and the Polk County Health Department provide much needed information to landowners regarding BMPs and give technical advice on practices or services that will benefit the land and water quality in the watershed.

Most importantly, the Bolivar Watershed Improvement Group is an excellent organization that works with these groups to implement watershed protection projects and goals. Being a non-profit organization, BCWIG is the natural organization to facilitate the work between agencies and residents of the watershed. For the past five years, BCWIG has facilitated projects and sponsored events to protect water quality in the Piper Creek and Town Branch watershed. Their organizational and economic sustainability is integral for further protecting this watershed.

The following list identifies educational opportunities that will be used to improve water quality education in the watershed.

1. Continue and sustain BCWIG coordination and funding for watershed management activities.
2. Create a Watershed Management position to oversee administrative, outreach and technical duties.
3. Publish a water quality newsletter and create/host a BCWIG website.
4. Implement a public awareness campaign regarding water quality with public service announcements.
5. Implement and host educational workshops for landowners and businesses.
6. Host local watershed festivals.

Monitoring Program & Strategy

Continued monitoring of the Town Branch/Piper Creek watershed will be integral in better understanding the dynamics of this watershed as well as evaluating the effectiveness of implemented action measures. It has been determined from existing evaluations and studies that there is general lack of water quality information in this watershed. A specific monitoring program will help to further define action measures and management strategies.

Currently, BCWIG and the Polk County Health Department monitor Town Branch through the Stream Team program. However, it has been determined by the Monitoring Committee of BCWIG that monitoring should be expanded and focused on two areas: TMDL studies and BMP monitoring for effectiveness. These expanded services can be contracted through local academic institutions.

Since the TMDL addresses Total Phosphorous, Total Nitrogen and Total Suspended Solids; it will be imperative to monitor for these constituents. The information generated will help cooperators to further delineate and address the sources contributing to nonpoint pollution. Monitoring for these constituents will also be complementary to the city of Bolivar's stormwater management program. Most importantly, a TMDL and BMP monitoring program will also help to cooperators evaluate the effectiveness of implemented best management practices.

Funding Estimates

The following chart is an estimate of costs to implement the watershed management plan. The numbers should be viewed as minimal and are subject to change.

Program/Timeframe	1-3 Years	4-7 Years	8-10 Years	Total
Riparian BMPs	$ 26,600	$49,000	$37,400	$113,000
Residential BMPs	$12,000	$21,000	$23,000	$56,000
Urban BMPs	$32,500	$65,000	$85,000	$182,500
Future BMPs for Undeveloped Areas	$35,000	$60,000	$85,000	$180,000
Education/Outreach Administration*	$171,000	$180,000	$189,000	$540,000
Monitoring Evaluation	$45,000	$20,000	$20,000	$85,000
Total	$322,100	$395,000	439,400	$1,156,500

* *Includes watershed management staff position*

Funding Options

In order to fund such operations, a financial strategy will have to be devised. This will include a diversity of options such as attaining grants and soliciting donations. Such grant opportunities include:

- Clean Water Act 319 Non-point source pollution grants (MO Dept. of Natural Resources/EPA)
- Urban Waters Small Grants (EPA-Office of Water)
- Targeted Watershed Grants Program (EPA)
- Urban and Community Forestry Challenge Cost Share Grants (U.S. Forest Service)
- Environmental Educational Grants Program (EPA)
- People's Garden Community Grant Program (U.S. Dept. of Agriculture)
- Community Foundation of the Ozarks

Introduction

Organizational Structure

The Bolivar Community Watershed Improvement Group (BCWIG) is a local non-profit organization made up of local residents representing a broad section of this community. This non-regulatory and voluntary organization was formed in 2005 to address the water quality issues impacting Bolivar and its surrounding areas. The purpose of BCWIG is to restore and enhance water quality conditions of the Town Branch watershed in order to improve and sustain the quality of life for the Bolivar and Polk County area. BCWIG implements its goals through water quality monitoring, educational and restoration activities. Different organizations and volunteers are assisting BCWIG and have assisted throughout the planning process. Cooperators such as the Polk County Health Department, City of Bolivar, the University of Missouri Extension, Natural Resources Conservation Service and numerous landowners and citizens are helping BCWIG to begin protecting the water resources of Bolivar.

2011-2012 BCWIG Board of Directors and Members

BCWIG Board of Directors and Members	
Delbert Simpson	Chairman
Kim Jarrell	Vice-Chairman
Sarena Simpson	Treasurer
Sam Kirby	Secretary
Susan Anderson	Member at Large
Larry Ferguson	Member at Large
John Lower	Member at Large
Jim Davis	Member at Large
Arleen Ferguson	Member at Large
Shirley Harris	Member at Large
Billy Dryer	Member at Large

BCWIG Technical Assistance Group

BCWIG Technical Assistance Group		
Ron Mersch	City Administrator	City of Bolivar
Rick Shuler	Director of Public Works	City of Bolivar
Bob Howe	District Conservationist	Natural Resources Conservation Service
Curtis Gooch	Resource Conservationist	Natural Resources Conservation Service
Adam Coulter	Water Quality Conservationist	Natural Resources Conservation Service
Susan Anderson	Environmental Health Specialist	Polk County Health Department
Bob Broz	Water Quality Specialist	University of Missouri Extension
Dan Downing	Water Quality Specialist	University of Missouri Extension

Bolivar Community Watershed Improvement Group

Watershed Planning Rationale

In 2008, BCWIG received a Clean Water Act, Section 319 watershed management planning grant by the Missouri Department of Natural Resources through the United States Environmental Protection Agency-Region VII. The purpose of this grant (and subsequent report) is to assess water quality impairment sources in the Town Branch watershed and to develop a comprehensive plan to address, reduce and deter further impairment. The Town Branch watershed is a tributary of Piper Creek which is designated as an impaired waterbody by the EPA through the Clean Water Act, Section 303(d) for waterways not meeting water quality standards (*http://dnr.mo.gov/env/wpp/waterquality/303d.htm*). Because of this, a Total Maximum Daily Load (TMDL) was established by United States Environmental Protection Agency in order to determine a level necessary to achieve applicable water quality standards (*http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/*). This TMDL process will be incorporated into the overall watershed management plan for Town Branch.

The watershed management planning process was achieved through a cooperative effort led by BCWIG with the assistance of many organizations and citizens. Public input meetings were held to discuss water quality issues and protection measures. Monthly meetings of BCWIG were also held to prioritize monitoring, planning, educational and restoration activities. This report will coalesce information that was generated over the past three years of this watershed planning process while providing guidance for future watershed protection activities. This watershed management planning process was implemented using the EPA's 9 key elements for watershed management plan development. These basic elements are listed as follows:

1. Identify the sources that will need to be controlled to reduce pollution levels.
2. Estimate the reductions expected.
3. Describe the management measures needed to achieve the pollution reductions.
4. Estimate of the amounts of technical and financial assistance needed.
5. Information/education components needed.
6. Schedule or timeline for the management plan.
7. Identify measurable milestones for determining whether management plan is working.
8. Set criteria to determine whether pollution reductions are being achieved over time.
9. Add a monitoring component to the plan that evaluates the effectiveness of the plan.

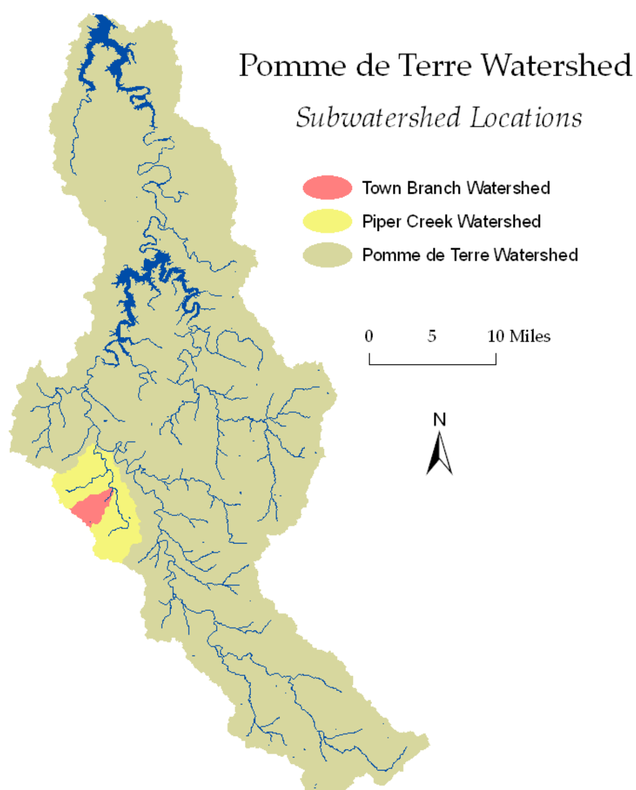
Watershed Location & Attributes

The Town Branch watershed is located within and partially outside the city limits of Bolivar Missouri. Encompassing over 3,800 acres, this waterbody drains into the Piper Creek watershed of the larger Pomme de Terre River watershed. Due to its urbanized location, water quality degradation is an issue that could potentially impact this waterbody as well as downstream water resources.

The Town Branch watershed is located in the Central Plateau subsection of the Ozark Highlands. The landtype association for this watershed is classified as the Bolivar Prairie/Savanna Plain. Historically, this area was dominated by a mosaic of tallgrass prairie and oak savanna communities. These gently rolling uplands were subject to repeated droughts and natural fires that restricted the development of forest communities. Trees such as post, black jack and black oaks were the prevalent species found in this area with bluestems being the dominant prairie grass. Very little of this historic vegetation remains with most of the prairies having been converted over to fescue pastures.

Pomme de Terre Watershed

The Pomme de Terre watershed encompasses approximately 840 square miles. Two impoundments exist in this watershed: Pomme de Terre Lake and Harry S. Truman Lake. Both waterbodies are operated by the United States Army Corps of Engineers for flood control, recreation and wildlife habitat. Additional information about the Pomme de Terre Watershed can be found at MDC's website "Missouri Watersheds" at *http://mdc.mo.gov/landwater-care/stream-and-watershed-management/missouri-watersheds*.

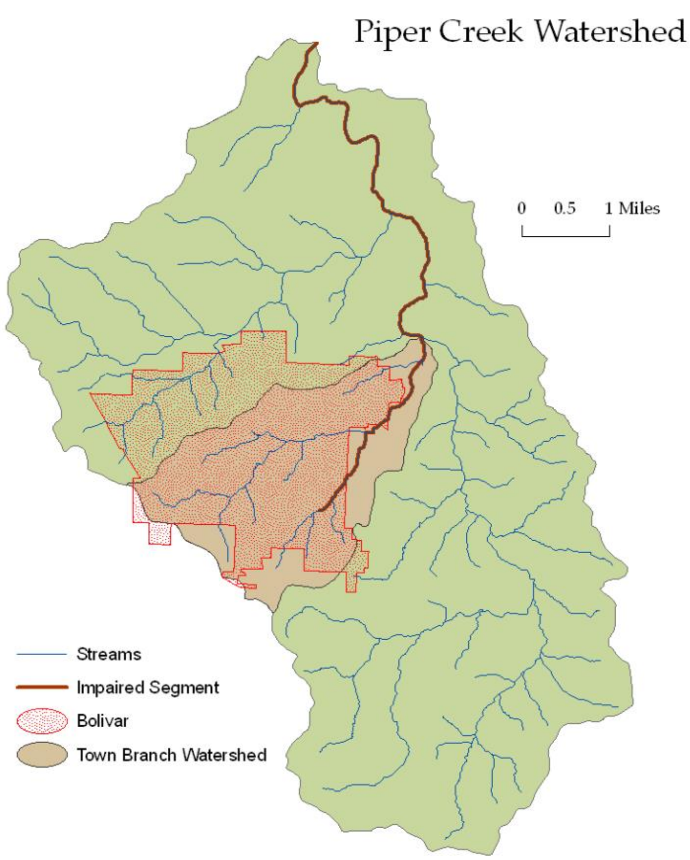


Piper Creek

As previously stated, Town Branch is part of the Piper Creek watershed. Encompassing 23,751 acres, Piper Creek is predominately a rural watershed with approximately 86% of its land uses being grasslands, forest and cropland covers. However 14% of this watershed is classified as urban cover mainly due to the city of Bolivar.

Land Use/Land Cover of Piper Creek Watershed

Land Use/Land Cover	Watershed Location		Percent
	Acres	Square Miles	
Impervious	1,682	2.6	7.1
High Intensity Urban	91	0.1	0.4
Low Intensity Urban	1,597	2.5	6.7
Barren or Sparsely Vegetated	171	0.3	0.7
Cropland	960	1.5	4.0
Grassland	14,887	23.3	62.7
Forest	2,993	4.7	12.6
Herbaceous	1,214	1.9	5.1
Wetland	26	0.0	0.1
Open Water	130	0.2	0.6
Total	23,751	37.1	100%

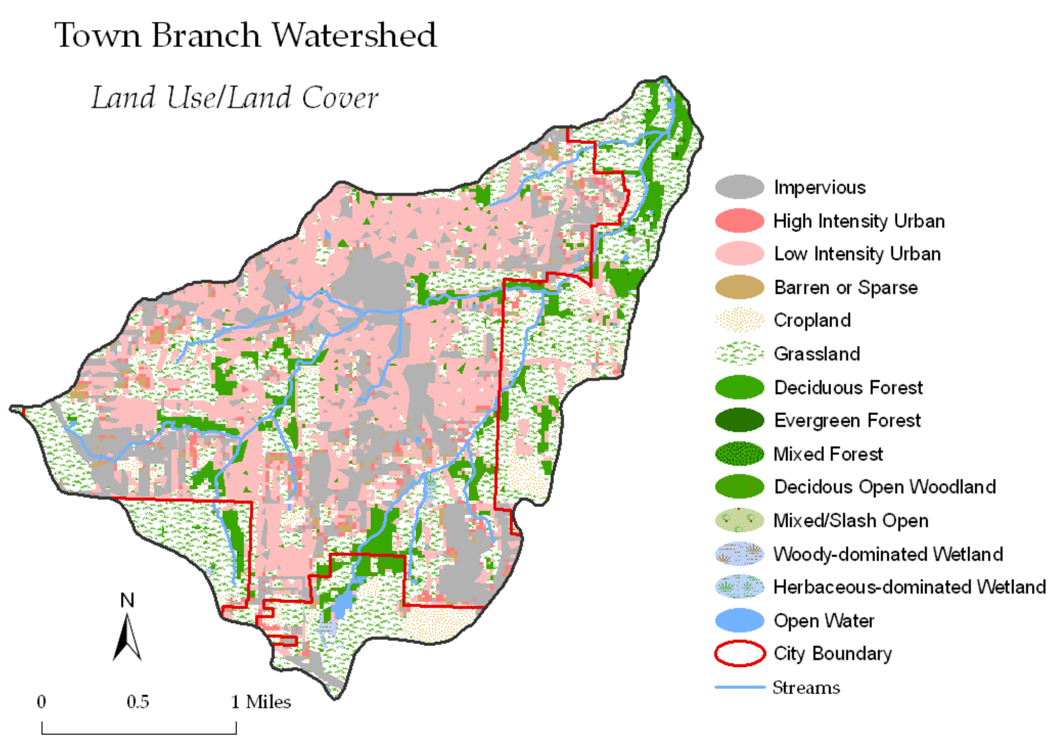


Town Branch

As previously stated, Town Branch is part of the Piper Creek watershed. Encompassing 3,800 acres, Town Branch is predominately an urban watershed with 67.6% being under urban cover. The city of Bolivar was founded upon Town Branch and has since grown throughout the watershed.

Land Use/Land Cover of Town Branch Watershed

Land Use/Land Cover	Watershed Location		Percent
	Acres	Square Miles	
Impervious	809.4	1.26	21.3
High Intensity Urban	45.6	0.07	1.2
Low Intensity Urban	1,713.8	2.68	45.1
Barren or Sparsely Vegetated	98.8	0.15	2.6
Cropland	106.4	0.17	2.8
Grassland	619.4	0.97	16.3
Forest	368.6	0.58	9.7
Herbaceous	7.6	0.01	0.2
Wetland	11.4	0.02	0.3
Open Water	19.0	0.03	0.5
Total	3,800	5.94	100%



Town Branch (continued)

Water Resource Assessment

Town Branch has 12.2 miles of stream within its watershed. Approximately 21 % of the delineated streams have permanent flow. Permanent flow is supplied from various springs and subsurface flow emanating from the shallow aquifer system.

Historically, Town Branch had greater base flow than it does now. Base flow conditions decreased over time due to the expansion of the city of Bolivar. This phenomenon is indicative in growing urban settings where impervious areas (such roads, buildings and parking lots) increase thus deterring groundwater infiltration while increasing peak discharges during rainfall events. The increase of peak discharges leads to flooding events, especially when development occurs in floodplains or low-lying areas. It has been documented that Town Branch has flooded periodically since the 1920's causing significant damage in certain situations.

Documented Historical Flooding Events

Year	Assessed Damage
May 1909	Damage to residential homes and stables. 16 inches in 18 hours.
August 1910	Christian Tabernacle Church heavily damaged.
September 1914	Bridges and ice plant washed out. 10 inches in 10 hours.
June 1924	Damage in business district near central confluence of Town Branch
March 1927	Residential houses damaged as well as power station. 5 inches in 48 hours.
August 1946	Sidewalk and street damage. Release of petroleum. 8.2 inches in 72 hours.
May 29, 2009	Flood damage in commercial/residential area in upper confluence floodway.

May 2009 Flood

May 2009 Flood

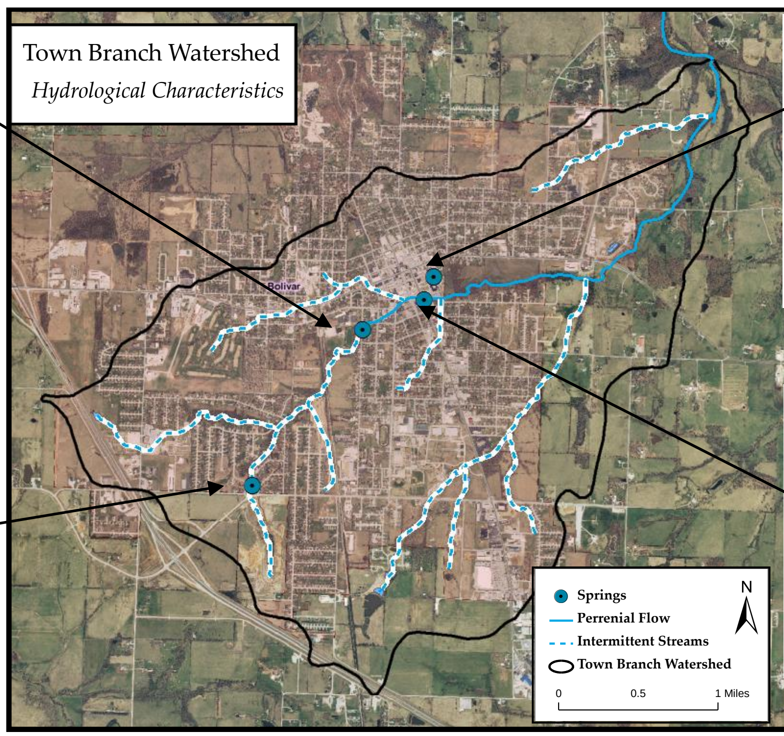
Water Resource Assessment (continued)

Many springs that once existed have since ceased to flow. Many of the historical springs were used as drinking water sources for the residential use. However due to non-point source pollution (namely from the lack of sanitary sewers and animal waste), many had to be abandoned due to environmental health concerns such as typhoid. It wasn't until 1912 that drinking water wells were drilled to supply citizens with clean potable water. Some of larger historical springs that were used for drinking water purposes still exist such as Town Spring and the Clark Spring (*also known as Girl Scout Park Spring*). Unfortunately, many springs either lost their subsurface flow, have become neglected and have since been filled in for development.

Documented Historical Springs

Name	Purpose/Provision (Date)	Current Condition
Town Spring	Main drinking water source (1869)	Non-potable and enclosed
Hendrickson Spring	Local water source/livestock watering (1886)	Graded with fill and unknown
Thompson Spring	Local water source/livestock watering (1886)	Unknown
Emerson Spring	Local water resource /private spring (1886)	Unknown
Clark Spring	Local water resource/livestock watering (1908)	Non-potable and enclosed
East Spring	Backup drinking water source(1908)	Non-potable and enclosed

Clark Spring



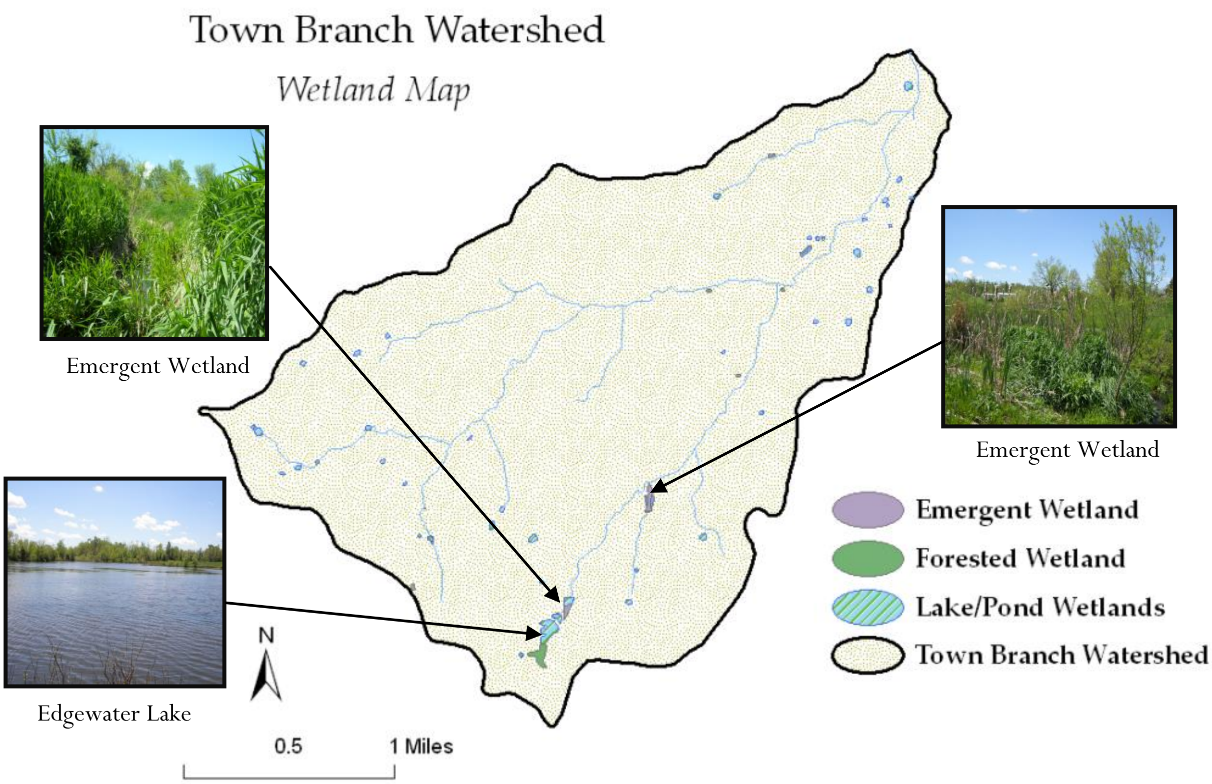
East Spring

Hendrickson Spring

Town Spring

Wetlands

Town Branch also has a small percentage of wetlands. Wetlands are areas that exhibit subsurface groundwater discharge and are classified as having permanent and/or seasonal water tables with hydric soils and certain types of aquatic fauna and flora. Examples of wetlands include springs, creeks, rivers and ponds. The total area of the wetlands in the Town Branch watershed equate to 23.08 acres or less than one percent of the total watershed area. The majority of the wetlands in this watershed are lake/pond wetlands. There are two delineated emergent wetlands. Emergent wetlands are characterized by erect, rooted, herbaceous shrubs and hydrophytes. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants and are seasonally flooded. These two emergent wetlands are found on the campus of Southwest Baptist University and at a spring located on undeveloped property (Edgewater Estates) south of South Pike Avenue. Forested wetlands are characterized as having trees larger than twenty feet. These too can be seasonally flooded and exhibit similar hydrophitic plants. The one forested wetland in the Town Branch watershed is also located at the undeveloped property south of South Pike Avenue.



Town Branch Wetlands

Wetland Type	Acres
Emergent Wetland	3.27
Forested Wetland	3.31
Lake/Pond Wetland	16.50
Total	23.08

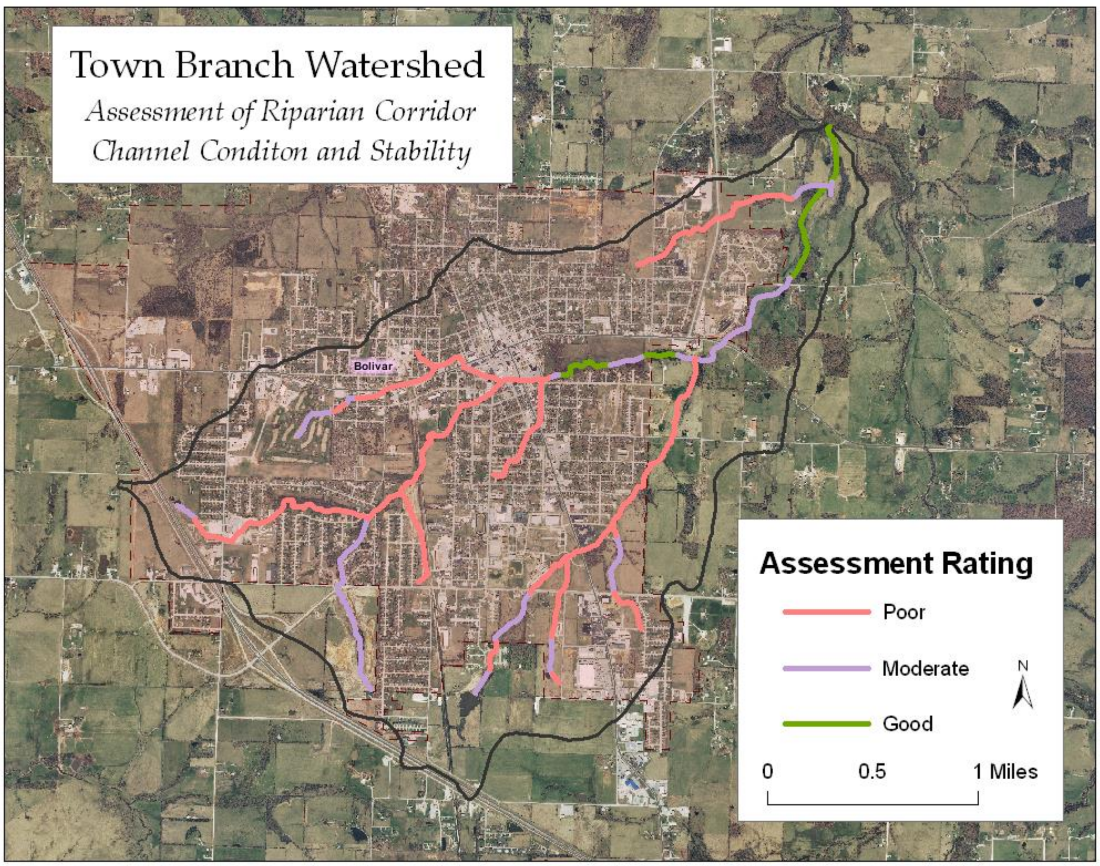
Riparian Conditions

A riparian area is the interface between land and a stream. Riparian areas can act as a buffer in protecting the health and integrity of a stream if it is properly managed. Riparian buffers help to protect stream bank stability while mitigating temperatures, providing wildlife habitat and acting as filter for polluted runoff.

Based on a study conducted by the Natural Resources Conservation Service in conjunction with Drury University, approximately 40% of the Town Branch watershed has an adequate riparian corridor. This study assessed the riparian corridors of the Town Branch watershed based upon certain attributes such as condition (diversity and health of flora, degree of succession) and width of the vegetative buffer. Streambank stability and geomorphic features (bedload, scouring) were also assessed.

Most of the riparian corridors that were deemed inadequate have little or no riparian buffer and exhibited signs of active erosion. Many of these sites have connected impervious areas leading into the channel or were levied next to the channel in order to prevent flooding.

Riparian Corridor Assessment of Town Branch



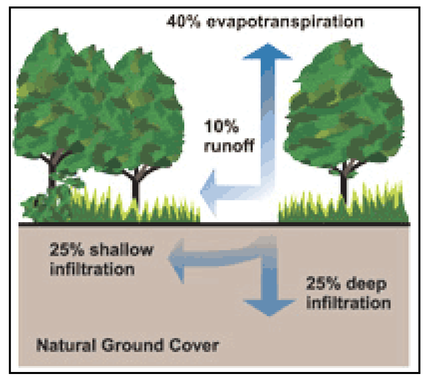
Rating	Length (*miles*)	Percentage
Good	1.2	10%
Moderate	3.7	30%
Poor	7.3	60%

Watershed Impacts of Urbanization

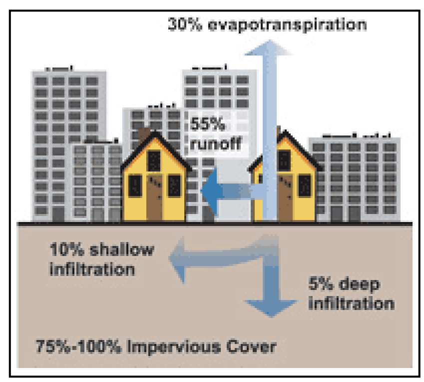
Background

Since the Town Branch watershed is primarily made up of commercial and residential land uses, it will be important to understand the impact urban land uses have on water quality. In urban and suburban areas, much of the land surface is covered by buildings and pavement, which do not allow rain and snowmelt to soak into the ground. Instead, most developed areas rely on storm drains to carry large amounts of runoff from roofs and paved areas to nearby waterways. The storm water runoff carries pollutants such as oil, dirt, chemicals and lawn fertilizers directly to streams and rivers, where they seriously harm water quality. To protect surface water quality and groundwater resources, development should be designed and built to minimize increases in runoff.

Increased Runoff



The porous and varied terrain of natural landscapes like forests, wetlands and grasslands traps rainwater and snowmelt and allows them to filter slowly into the ground. In contrast, impervious (nonporous) surfaces like roads, parking lots and rooftops prevent rain and snowmelt from infiltrating, or soaking, into the ground. Most of the rainfall and snowmelt remains above the surface, where it runs off rapidly in unnaturally large amounts.



Storm sewer systems concentrate runoff into smooth, straight conduits. This runoff gathers speed and erosional power as it travels underground. When this runoff leaves the storm drains and empties into a stream, its excessive volume and power blast out streambanks, damaging streamside vegetation and wiping out aquatic habitat. These increased storm flows carry sediment loads from construction sites and other denuded surfaces and eroded streambanks. They often carry higher water temperatures from streets, roof tops and parking lots, which are harmful to the health and reproduction of aquatic life.

The loss of infiltration from urbanization may also cause profound groundwater changes. Although urbanization leads to great increases in flooding during and immediately after wet weather, in many instances it results in lower stream flows during dry weather. Many native fish and other aquatic life cannot survive when these conditions prevail.

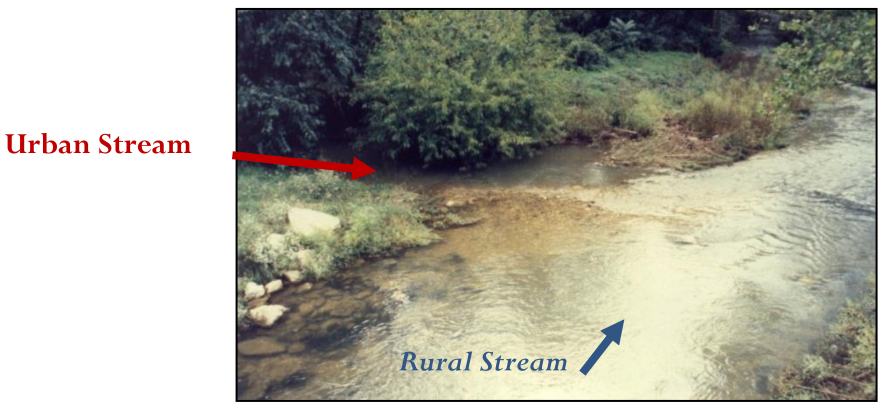
Increased Pollutant Loads

Urbanization increases the variety and amount of pollutants carried into streams, rivers and lakes. The pollutants include:

- Sediment
- Oil, grease and toxic chemicals from motor vehicles
- Pesticides and nutrients from lawns and gardens
- Viruses, bacteria and nutrients from pet waste and failing septic systems
- Road salts
- Heavy metals from roof shingles, motor vehicles and other sources
- Thermal pollution from dark impervious surfaces such as streets and rooftops

These pollutants can harm fish and wildlife populations, kill native vegetation, foul drinking water supplies, and make recreational areas unsafe and unpleasant.

Example of urban runoff on water resources



Before rainfall event

After rainfall event

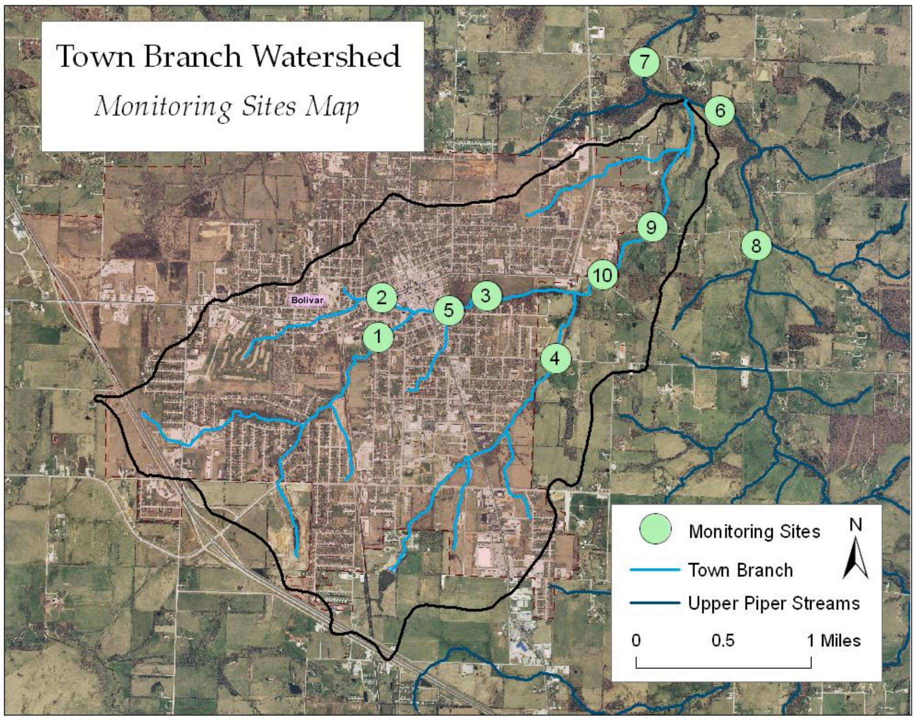
The following pictures display an urban watershed's impact on a rural stream after a small rainfall event. The urban watershed has an approximate impervious area of 25% while the rural watershed has an impervious area of 3 %. Note the sediment plume impacting this waterbody.

Bolivar Community Watershed Improvement Group

Water Quality Conditions

Monitoring Sites

Water quality conditions in the Town Branch watershed have been regularly monitored since 2006 by the Polk County Health Department. Ten monitoring sites were selected based upon the locality of tributaries, point sources and control factors. The following map represents the general location of these sites.



Site	Location	Latitude/Longitude
1	Town Branch at Girl Scout Park	Lat. 37.36593, Lon. 093.24839
2	Town Branch at Clark Street bridge in front of Robert's Chevrolet	Lat. 37.36816, Lon. 093.24905
3	Town Branch north of 301. S. Chicago Street (below residence)	Lat. 37.36797, Lon. 093.24225
4	Town Branch at Buffalo Road bridge	Lat. 37.36489, Lon. 093.23844
5	Town Branch at Albany Ave. bridge at Walnut St. junction	Lat. 37.61205, Lon. 093.40777
6	Piper Creek 1000 ft above Town Branch entry	Lat. 37.62924, Lon. 093.38120
7	Piper Creek, 200 ft upstream of E. 425 Rd., below Town Br. entry	Lat. 37.63335, Lon. 093.38780
8	Piper Creek, 200 ft upstream side of E. 435 Rd.	Lat. 37.61572, Lon. 093.37582
9	Town Branch, downstream side of E. 435 Rd	Lat. 37.62102, Lon. 093.37582
10	Town Branch, between WWTP discharge and Highway 32	Lat. 37.61592, Lon. 093.39022

Water Quality Factors

The physical, chemical and biological attributes that were monitored include temperature, pH, dissolved oxygen, conductivity, turbidity, phosphorus, and nitrogen and macroinvertebrate diversity. Descriptions of the parameters measured are discussed below.

Temperature

Temperature is an important physical feature that is integral in the health of streams. In urban watersheds, thermal pollution can have a significant impact on water quality and aquatic life. Water temperatures can dramatically rise during stormwater runoff events due to the heat that (surface) impervious areas absorb. Direct sunlight can also increase the temperature of streams especially where there is no riparian corridor to provide shade. Increased water temperatures also adversely impact dissolved oxygen levels thus facilitating algal growth. Algae growth rapidly increases when the temperature rises. Thus the response of aquatic plants to nutrient inputs during winter is less pronounced than during summer.

Shade from riparian vegetation and decreasing the width-to-depth ratio of streams are primary strategies for lowering temperatures. Another strategy is to disconnect impervious areas (thus creating areas of filtration and longer residence times for stormwater to cool off) before runoff can reach a stream.

pH

pH is an important limiting chemical factor for aquatic life. If the water in a stream is too acidic or basic, the H+ or OH- ion activity may disrupt biochemical reactions by either harming or killing the stream organisms. pH is expressed in a scale with ranges from 1 to 14. A solution with a pH less than 7 has more H+ activity than OH-, and is considered acidic. A solution with a pH value greater than 7 has more OH- activity than H+, and is considered basic. The pH scale is logarithmic, meaning that as you go up and down the scale, the values change in factors of ten. A one-point pH change indicates the strength of the acid or base has increased or decreased tenfold.

Streams generally have a pH values ranging between 6 and 9, depending upon the presence of dissolved substances that come from bedrock, soils and other materials in the watershed. Changes in pH can change the aspects of water chemistry. For example, as pH increases, smaller amounts of ammonia are needed to reach a level that is toxic to fish. As pH decreases, the concentration of metal may increase because higher acidity increases their ability to be dissolved from sediments into the water.

Dissolved Oxygen

Dissolved oxygen (DO) is another important attribute in aquatic systems. Micro-organisms, plants and animals take up and utilize dissolved oxygen from the water. Many organisms begin to be affected adversely when dissolved oxygen levels go below 6 mg/L. As stated previously, an increase in temperature lowers dissolved oxygen concentrations.

Human activities can significantly impact dissolved oxygen levels. Removal of riparian vegetation may lower oxygen concentrations due to increased water temperature resulting from a lack of canopy shade and increased suspended solids resulting from erosion of bare soil. Typical urban human activities may lower oxygen concentrations. Runoff from impervious surfaces bearing salts, sediments and other pollutants increases the amount of suspended and dissolved solids in stream water. Organic wastes and other nutrient inputs from sewage and industrial discharges, septic tanks and agricultural and urban runoff can result in decreased oxygen levels. Nutrient inputs often lead to excessive algal growth. When the algae die, the organic matter is decomposed by bacteria. Bacterial decomposition consumes a great deal of oxygen.

Conductivity

Conductivity is a measure of how well water can pass an electrical current. It is an indirect measure of the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron and aluminum. The presence of these substances increases the conductivity of a body of water. Organic substances like oil, alcohol, and sugar do not conduct electricity very well, and thus have a low conductivity in water.

Inorganic dissolved solids are essential ingredients for aquatic life. They regulate the flow of water in and out of organisms' cells and are building blocks of the molecules necessary for life. A high concentration of dissolved solids, however, can cause water balance problems for aquatic organisms and decrease dissolved oxygen levels. In streams, higher conductivity will sometimes indicate the presence of springs or subsurface water since groundwater has a higher conductivity than surface water.

Turbidity

Turbidity is a measure of the cloudiness of water. Cloudiness is caused by suspended solids (mainly soil particles) and plankton (microscopic plants and animals) that are suspended in the water column. Moderately low levels of turbidity may indicate a healthy, well-functioning ecosystem, with moderate amounts of plankton present to fuel the fuel the food chain. However, higher levels of turbidity pose several problems for stream systems. Turbidity blocks out the light needed by submerged aquatic vegetation. It also can raise surface water temperatures above normal because suspended particles near the surface facilitate the absorption of heat from sunlight. Suspended soil particles may carry nutrients, pesticides, and other pollutants throughout a stream system. High turbidity may result from sediment bearing runoff, or nutrients inputs that cause plankton blooms. High turbidity is also correlated to the release of phosphorous into the water since agitation can facilitate the release of phosphorus from soil particles. Turbidity is measured in Nephelometric Turbidity Units (NTU).There are no numeric turbidity standards for the State of Missouri, however a measurement of above 25 NTUs is generally a cause for concern.

Phosphorus

Phosphorus is an essential element for life. It is required for membrane stability and nucleic acids (DNA and RNA). It occurs in various forms-either as dissolved (inorganic) or particulate (organic) forms. Dissolved phosphorus is more readily available for uptake by aquatic plants such as algae. Examples of particulate forms include phosphorus locked up in plant residue, manure or soil. These forms are generally released over time through decomposition or agitation and thus are converted over into dissolved phosphorus.

Elevated levels of phosphorous (and nitrogen) can greatly impair streams through the proliferation of algal blooms. Since phosphorous is a major source for plant growth, elevated levels can increase unwanted algal growth in streams. When alga dies, microbes will decompose the plant material. In this process, dissolved oxygen levels become depleted. These lower oxygen levels can facilitate fish kills and impair other aquatic organisms.

The levels monitored in the Town Branch watershed are of dissolved phosphorus. The EPA water quality criteria state that phosphates should not exceed .05 mg/l if streams discharge into lakes or reservoirs, .025 mg/L within a lake or reservoir, and .1 mg/L in streams or flowing waters not discharging into lakes or reservoirs to control algal growth. However, the Department of Natural Resources also recommends that the in-stream total phosphorus for the James River should not exceed .075 mg/L.

Nitrogen

Nitrogen is another nutrient that is essential for life. Much like phosphorus, nitrogen occurs as dissolved (inorganic) or particulate (organic) forms. Nitrogen occurs in natural waters in various forms, including nitrate (NO_3), nitrite (NO_2), and ammonia (NH_3). Nitrate is the most common form tested. Test results are usually expressed as nitrate-nitrogen (NO_3-N), which simply means nitrogen in the form of nitrate. Ammonia is the least stable form of nitrogen and thus difficult to measure accurately. Nitrite is less stable and usually present in much lower amounts that nitrate. Organic nitrogen is found in proteins and is continually recycled by plants and animals. These three compounds are interrelated through the process of nitrification, the biological oxidation of ammonia to nitrate. In this process nitrite is produced as an intermediate product.

Order of decreasing oxidation state for nitrogen

Nitrate⟶ Nitrite⟶ Ammonia⟶ Organic Nitrogen

(Stable→ → →→ → →→→ → →→ → →→Unstable)

Dissolved nitrogen is more readily available for uptake by aquatic plants such as algae. Examples of particulate forms include plant residue, manure or soil. Nitrogen is less stable than phosphorus and can quickly be converted over to ammonia.

Nitrogen-containing compounds act as nutrients in streams and rivers. Nitrate reactions [NO3-] in fresh water can cause oxygen depletion. Thus, aquatic organisms depending on the supply of oxygen in the stream will die. The major routes of entry of nitrogen into bodies of water are municipal and industrial wastewater, septic tanks, feed lot discharges, animal wastes (including birds and fish) and discharges from car exhausts. Bacteria in water quickly convert nitrites [NO2-] to nitrates [NO3-].

Nitrites can produce a serious condition in fish called *brown blood disease*. Nitrites also react directly with hemoglobin in human blood and other warm-blooded animals to produce methemoglobin. Methemoglobin destroys the ability of red blood cells to transport oxygen. This condition is especially serious in infants under three months of age. It causes a condition known as methemoglobinemia or blue baby syndrome. Water with nitrite levels exceeding 1.0 mg/L should not be used for feeding babies. Nitrite/nitrogen levels below 90 mg/l and nitrate levels below 0.5 mg/L seem to have no effect on warm water fish. However, nitrate levels above 0.65 mg/L will facilitate algal growth and are deemed eutrophic.

Discharge

Discharge is the measure of the flow rate of a stream. It is typically measured in cubic feet per second (cfs). The samples taken where during base flow conditions when there was no influence from storm water runoff or drought episodes. Discharge rises dramatically during storm water runoff events. Subsequently, when discharge rises, a larger concentration of pollutants is detected; this is known as the *first flush* effect.

Macroinvertebrate Diversity

Macroinvertebrates are benthic organisms that live in freshwater streams. They are good indicators of water quality because they are permanent residents of the stream and can move only short distances. This makes them susceptible to any pollutants that may be in the water. Some pollutants "pulse" through the water and may impact various communities. Examples of macroinvertebrates include mayflies, caddisflies, stoneflies, crayfish, scuds and various aquatic worms. The methodology for determining the diversity of macroinvertebrates is based on the Missouri Stream Teams protocol.

Results of Data

INDIVIDUAL TEST SITE AVERAGES

2006-2010

SITE #	1	2	3	4	5	6	7	8	9	10
Temperature (°*F*)	65.8	71.6	61.7	64.9	62.6	62.6	63.1	67.6	66.2	66.0
pH	7.8	8	8	8.1	8.2	8.3	8.3	8.2	7.6	8.4
DO (*mg/L*)	8.75	12	11.25	9.25	11	14.6	13.6	10	10	12.5
Conductivity	411	540	526	425	596	396	500	371	614	475
Turbidity (*NTU*)	10	15	10	13	13	10	10	13	12	10
Phosphate (*mg/L*)	0.63	0.31	0.23	0.40	0.81	0.25	0.81	0.18	3.2 1.124	na 0.137
Nitrate (*mg/L*)	1.28	0.82	4.00	1.00	0.5	0.29	4.00	0.32	7.00	1.6
Flow Rate (CFS)	2.63	*na*	1.83	1.39	0.44	9.13	22.98	4.81	5.7	7.09
Macroinvertebrate Diversity	Good	Poor	Good	Fair	Poor	Excellent	Excellent	Good	Fair	*na*

***BCWIG/Polk County Health Department in Black** (quarterly monitoring 2006-2010, n=8)*

***City of Bolivar measurements in Red** (quarterly monitoring 2008-2010, n=10)*

Results of Data (*continued*)

The physical, chemical and biological attributes that were monitored include temperature, pH, dissolved oxygen, conductivity, turbidity, phosphorus, and nitrogen and macroinvertebrate diversity. An analysis and correlation of the results will be discussed in the latter section.

Temperature

The average temperatures taken are relatively constant throughout the various sites that were monitored. However, Site 2 has a large discrepancy in average temperature with the rest of sites. On the average, Site 2 is 3.9° Fahrenheit degrees higher than the rest of the other sites. This indicates that areas upstream of Site 2 are greatly influencing water temperature. The area upstream of Site 2 has a poorly riparian corridor. Further on-site investigations have concluded that the riparian corridor has poor stream shade with little base flow. This corresponds greatly with the poor macroinvertebrate population found at this site.

pH

The average pH measurements range from 7.6 to 8.4 throughout the monitoring sites. This relatively constant range indicates that there are no anomalies in regards to the acidity or basic attributes of the streams. Site 9 is slightly more acidic which is due to the influence of treated waste water discharging into Town Branch (and it should be noted that the waste water treatment plant does not influence the pH of Piper Creek at all).

Dissolved Oxygen

The average dissolved oxygen levels monitored indicate sustainable and healthy concentrations. No levels were recorded below 6 mg/L.

Conductivity

Conductivity levels are also constant for the sites monitored throughout the sampling regime. The highest level of average conductivity is located at Site 9 below the waste water treatment plan (which is expected).

Turbidity

The average turbidity levels measured during base flow conditions were well below the 25 NTU mark. This indicates that there is no concern during base flow conditions. However, NTU levels can dramatically increase during storm water runoff events.

Phosphorus

Average phosphate levels ranged from 0.18 mg/L to 3.2 mg/L throughout the watershed. All of these sites exceed the threshold mark of 0.075 mg/L established for the James River by the Missouri Department of Natural Resources. This should not be unexpected. Urban streams typically have elevated levels of phosphorus due the amount of phosphates found in an urban sector as well as the high degree of impervious areas. The highest level of phosphorus was found at below the Bolivar waste water treatment plant. The lowest amounts were found on Piper Creek above the Town Branch confluence.

Nitrogen

The average nitrate levels sampled in the Town Branch watershed varied from .29 mg/L to 7.0 mg/L. The highest level detected is located below the outfall of the Bolivar waste water treatment plant. The lowest amounts were found in the Piper Creek above the Town Branch confluence. Though nitrogen is unstable, this information when correlated to phosphate levels will identify areas of nutrient loading inputs.

Analysis of Data

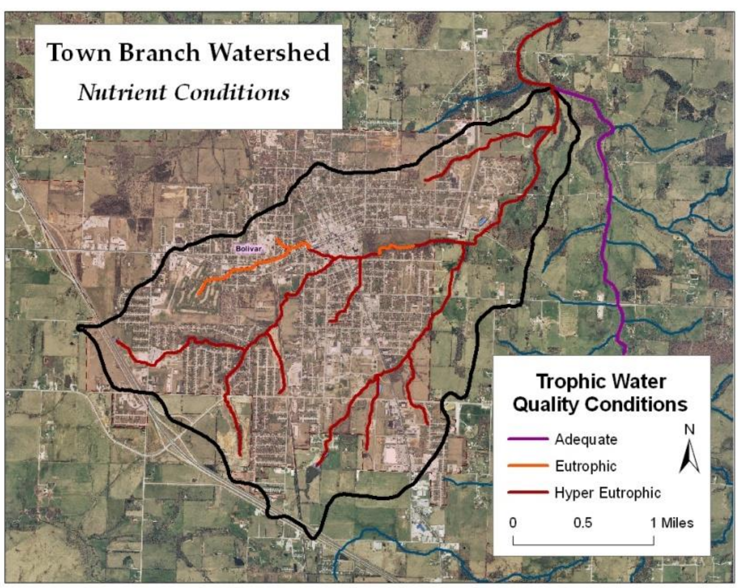
Nutrient Loading & Eutrophication

Nutrient levels within the Town Branch watershed play an important factor in impacting the trophic state of water quality conditions. Trophic water quality conditions refer to the overall level of nutrients and related algae/plant growth within a water body. There are various types of trophic states. Mesotrophic conditions exist where there are intermediate levels of nutrient supplies. Eutrophic conditions are systems that have a large supply of nutrients that proliferate algal production. Hypereutrophic conditions exhibit large concentrations of nutrients to where algae and aquatic plants become a major nuisance.

Nutrient levels of both phosphates and nitrates indicated a strong correlation with land use, riparian conditions and point and non-point sources. The lowest levels of nutrients were monitored on Sites 6 and 8 on Piper Creek before its confluence with Town Branch. Though the upper Piper Creek watershed is mainly agriculture, it can be correlated that a significant amount of nutrient loading does not come from this area. This could be due to the passive land use of haying grassland and the proper management of agricultural operations such as livestock exclusion from waterways, proper fertilization techniques/manure handling and riparian corridor protection.

The highest nutrient levels were found to be on Site 9 below the Bolivar waste water treatment plant. This is expected since waste water treatment facilities typically discharge elevated levels of phosphorus and nitrogen. However, the influence of nutrient nonpoint sources has taken on greater significance as waste water treatment technologies have improved and are regulated to meet certain effluent standards.

Excluding the waste water treatment plan influence, the highest nutrient levels found in the Town Branch watershed were found at Sites 1 and 5. These sites are under the influence of residential and commercial areas. Areas upstream of these sites have connected impervious areas which influence the degree of storm water runoff events making the channels in these areas very unstable. The instability of channels facilitates stream bank erosion which can release phosphorus into the water column. Most importantly, these sites have a lack of riparian cover and buffer. Subsequently, the lowest nutrient levels in the Town Branch watershed were found at Site 3 where there is a good riparian corridor.



Piper Creek/Town Branch TMDL

Piper Creek is listed on the Missouri Department of Resources 303(d) List for Impaired Waterbodies due to high levels of organic sediment. Section 303(d) of the federal Clean Water Act requires that each state identify waters that are not meeting water quality standards and for which adequate water pollution controls have not been required. Water quality standards protect such beneficial uses of water as whole body contact and secondary contact recreation, maintaining fish and other aquatic life, and providing drinking and processing water for people, wildlife, livestock and industry. The 303(d) list helps state and federal agencies keep track of waters that are impaired but not addressed by normal water pollution control programs.

The area of impairment in this watershed begins on the southern Town Branch section starting from Springfield Avenue and flowing into Piper Creek. This impairment continues for the duration of Piper Creek (approximately 7.5 miles) until its confluence with the main stem of the Pomme de Terre River.

TMDL Definition and Methodology

In order to address the sources of impairment, a Total Maximum Daily Load (TMDL) was calculated. A TMDL is a term in the Clean Water Act, describing a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards. Alternatively, TMDL is an allocation of that water pollutant deemed acceptable to the subject receiving waters.

In order to calculate such a level, the U.S. Environmental Protection Agency collected water quality data over a two day period in July and August of 2009. The data generated was modeled utilizing the QUAL2K method to where loading capacity and allowable allocations could be determined. Further detail of this method and results are located in Appendix A of this report.

Sources of Impairment and Pollutants

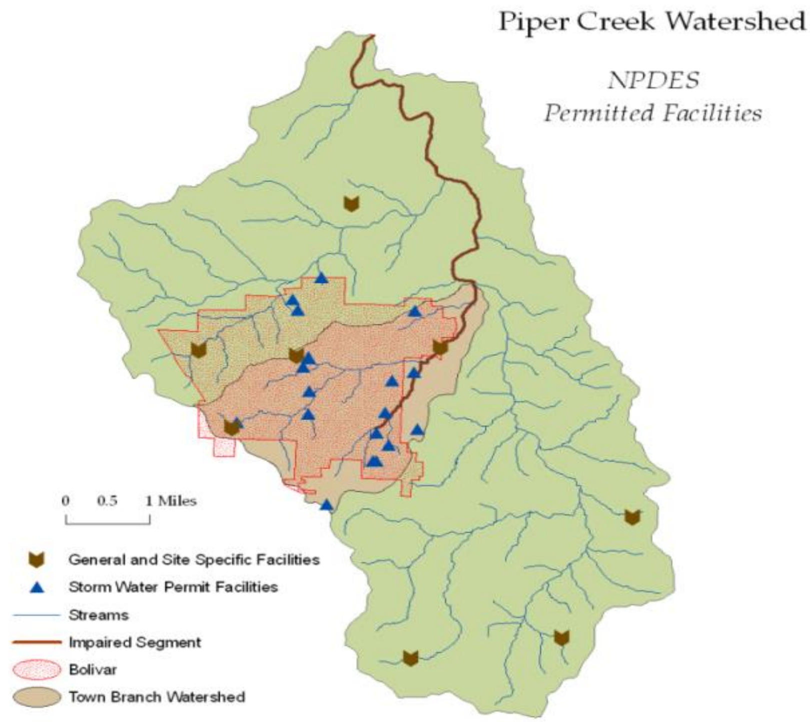
From the information generated through assessment, monitoring and modeling techniques, the identified source of impairment is listed as the City of Bolivar Waste Water Treatment Facility and other unknown sources. Evidence supports that the other unknown sources are emanating different point and non-point sources. The pollutants identified and subsequently addressed in the TMDL are nutrients (total phosphorus and total nitrogen), sediment (total suspended sediment), and low dissolved oxygen.

Point and Non-Point Pollution

Point sources refer to any discernible, confined or discrete conveyances, such as drainage pipes, channels and conduits, by which pollutants are transported to a water body. These sources are typically regulated by a local, state or federal authority due to the concentration and level of pollutants being discharged.

Non-point sources include generalized contributors of pollutants that emanate from non-discernible sources that are difficult to measure. Such areas include runoff from agriculture and urban areas, on-site wastewater systems and degraded channel and riparian conditions such as stream bank erosion. Due to the size and complexity of these sources, they are typically not regulated but are addressed through education, the implementation of local standards and cost-share assistance.

Permitted Point Source Sites



According the National Pollutant Discharge Elimination System (NPDES) program, there are five site-specific permits, three general permits and twelve storm water-permitted sites. The site-specific permits include municipal and industrial wastewater facilities (WWTF). These facilities must meet certain pollutant criteria before wastewater is discharged into a stream. General permitted sites include on-going businesses such as quarries or petroleum facilities that must implement best management practices in order to deter stormwater runoff and hazardous waste impacts. They too have discharge sampling requirements. The stormwater permitted facilities are those businesses that either transfer and sell agrochemicals, metal scrap or recycle automobiles. The other stormwater permits are for construction sites where land disturbance occurs. These land disturbance sites are required to submit a Storm Water Pollution Prevention Plan that details how sediment and erosion are addressed during construction.

2010 Permitted Point Sources in Town Branch

Facility Name	Permit Classification/Description
City of Bolivar WWTF	Site Specific Permit-Sewerage System
Home Court Advantage, Inc. WWTF	Site Specific Permit-Sewerage System
Quail Mobile Home Park WWTF	Site Specific Permit-Sewerage System
Silo Ridge Homeowners Association WWTF	Site Specific Permit-Sewerage System
Karlin Place Subdivision WWTF	Site Specific Permit-Sewerage System
Carl White Oil Company	General Permit-Bulk Terminal Petroleum Station
Ewing Concrete Materials	General Permit-Crushed Stone Facility
Bolivar Ready M ix & Material	General Permit-Crushed Stone Facility
Industrial Development	Stormwater Permit-Land Disturbance (Construction)
Burlington Heights Subdivision	Stormwater Permit-Land Disturbance (Construction)
Monarch Landing	Stormwater Permit-Land Disturbance (Construction)
Settler's Village	Stormwater Permit-Land Disturbance (Construction)
Walgreen's	Stormwater Permit-Land Disturbance (Construction)
Stonebridge Estates	Stormwater Permit-Land Disturbance (Construction)
Aldi	Stormwater Permit-Land Disturbance (Construction)
Highline Village	Stormwater Permit-Land Disturbance (Construction)
Tracker Marine	Stormwater Permit-Electrical and Metal Operation
Bolivar Farmers Exchange Fertilizer	Stormwater Permit-Farm Supplies Operation
Hawk Fertilizer	Stormwater Permit-Farm Supplies Operation

TMDL Summary for Piper Creek

In 2010, a Total Maximum Daily Load (TMDL) was established by the United States Environmental Protection Agency in order to determine a level necessary to implement applicable water quality standards. As previously stated the identified source is listed as the City of Bolivar Waste Water Treatment Facility and other unknown sources. Evidence supports that the other unknown sources are emanating different point and non-point sources.

The following information summarizes the established TMDL for Town Branch and Piper Creek.

Parameter Pollutant	Baseline Conditions			TMDL			Non-point Reduction %	Point Source Reduction %
	Point Sources	Nonpoint Sources	Total	Point Sources	Nonpoint Sources	Total		
Flow	4.026	0.071	4.096	4.026	0.071	4.096	0	0
BOD	654.9	1.4	656	120.5	0.5	121	82	63
NBOD	No limit	2.8	Not applicable	136.8	1.0	137.8	Not applicable	65
NH	30	0.2	30.2	30	0.1	30.1	0	42
TSS	594	No applicable data	Not applicable	192	3	195	68	See LDC
TN	No limit	1.1	Not applicable	6.3	0.1	6.4	Not applicable	See LDC
TP	No limit	0.02	Not applicable	0.15	0.003	0.15	Not applicable	See LDC

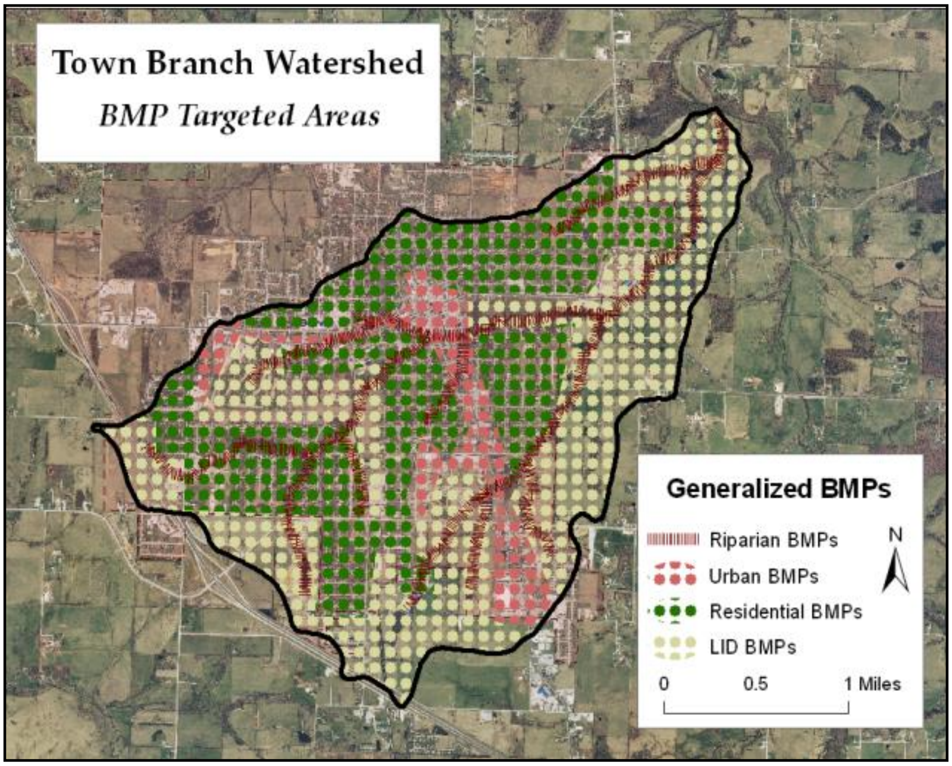
Pollutant/Parameter	**Definition**
Flow	Amount of water or discharge flowing through the stream. Measured in cubic feet per second (cfs).
BOD	Biochemical Oxygen Demand is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. Measured in pounds per day.
$NBOD_{ult}$	Nitrogenous Biochemical Oxygen Demand. Similar to BOD but incorporates oxidizable nitrogen. Measured in pounds per day.
NH_3	Ammonia. Measured in pounds per day.
TSS	Total Suspended Solids. Measured in pounds per day.
TN	Total Nitrogen. Measured in pounds per day.
TP	Total Phosphorous. Measured in pounds per day.
LDC	Load Duration Curve. A method to determine percent of reduction based on flow conditions.
*	Percent of reduction needed to achieve TMDL level.

Pollutant	Current Load*	TMDL*	Reduction
Total Nitrogen	1.1 lbs/day	0.1 lbs/day	1.0 lbs/day (91%)
Total Phosphorus	0.02 lbs/day	0.003 lbs/day	0.017 lbs/day (85%)
Total Suspended Solids	No applicable data	3.0 lbs/day	Not applicable

* As calculated by montioring
** The amount needed to reach water quality standards

Critical Pollutant Areas

In order to address the pollution concerns as stipulated in the TMDL, the Town Branch watershed was assessed through various methods in order to determine critical areas of concern and pollutant contribution. Based upon on-site assessments, water quality data and land use patterns; a critical pollutant map was created to prioritize areas of concern.



It is important to note that the areas identified can be addressed by implementing various structural and non-structural BMPs. The map displays areas where generalized BMPs can be implemented. In the following sections, a more detailed analysis of specific BMP stratgies and milestones will be provided that will help to reduce the loading of water quality pollutants. The areas identified as critical are further analyzed for pollutant contribution in the following sections as well.

Poorly Vegetated Riparian Corridor

Construction Site Runoff

Critical Pollutant Contributions

The following table summarizes and describes the pollutant influence of the identified critical areas. The pollutant loads and contributions were calculated based on the STEPL model as well as incorporating water quality data, land uses and area.

Critical Area	Description/Issues	Pollutant Load	Percent of Contribution
Riparian	Areas along the riparian corridor where cuts banks, active streambank erosion, poor buffer width and lack of vegetative diversity contribute to total suspended solids, phosphorus and nitrogen loads.	TN=.28 lbs/day TP= 0.0066 lbs/day	TN= 25.5% TP = 33.0%
Urban	Areas of concentrated and connected impervious structures such as buildings, parking lots and roads that contribute to total suspended solids, phosphorus, nitrogen, heavy metal, and volatile organic compound loads.	TN=.23 lbs/day TP= 0.0060 lbs/day	TN= 20.9% TP = 30.0%
Residential	Areas of residential developments where lawn fertilizers, pet waste and waste water systems are present and contribute to phosphorous, nitrogen and bacteria loads.	TN=.55 lbs/day TP= 0.0066 lbs/day	TN= 50.0% TP = 33.0%
Undeveloped	These areas are undeveloped parcels which contribute minimal pollutant loads. These are areas are anticipated to become developed as residential, commercial or industrial ventures.	TN= 0.04 lbs/day TP= 0.0008 lbs/day	TN= 3.6% TP = 4.0%

The following chart visually displays the contribution of land uses to water quality impairment in the Town Branch watershed.

Load Reduction Milestones

Based upon the best management practices that could be employed in each critical area, a plan for reducing pollutant loads can be estimated in order to achieve water quality standards. The following tables display the reduction loads for specific practices over a reasonable period of time. Calculations were based on the STEPL method and BMP calculator.

Riparian BMPs

BMP	1-3 Years		4-7 Years		8-10 Years	
	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)
Stream Bank Stabilization	7 sites	TN=0.081 TP=0.001	10 sites	TN=0.115 TP=0.002	10 sites	TN=0.115 TP=0.002
Buffer Establishment	11,600 ft.	TN=0.017 TP=0.0006	29,000 ft.	TN=0.042 TP=0.0012	17,400 ft.	TN=0.025 TP=0.0009

Residential BMPs

BMP	1-3 Years		4-7 Years		8-10 Years	
	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)
Water Quality Detention Basins	4 sites	TN=0.063 TP=0.000754	5 sites	TN=0.079 TP=0.000943	5 sites	TN=0.079 TP=0.000943
Nutrient Management Plans	50 sites	TN=0.0231 TP=0.000283	100 sites	TN=0.0462 TP=0.000565	200 sites	TN=0.0924 TP=0.001131
Rain Gardens	10 sites	TN=0.022 TP=0.000264	20 sites	TN=0.044 TP=0.000528	20 sites	TN=0.044 TP=0.000528
Low Impact Landscaping	10 sites	TN=0.011 TP=0.00013	20 sites	TN=0.022 TP=0.000264	20 sites	TN=0.022 TP=0.000264

Urban BMPs

BMP	1-3 Years		4-7 Years		8-10 Years	
	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)	Number	Reduction (lbs/day)
Curb Inlet Filters	5 sites	TN=0.00575 TP=0.00015	10 sites	TN=0.0115 TP=0.0003	5 sites	TN=0.00575 TP=0.00015
Permeable Pavement	.5 acres	TN=0.0138 TP=0.00036	1 acre	TN=0.0276 TP=0.00072	2 acres	TN=0.0552 TP=0.00144
Bioretention Cells	5 sites	TN=0.023 TP=0.0006	10 sites	TN=0.046 TP=0.0012	10 sites	TN=0.046 TP=0.0012
Green Roofs	1 site	TN=0.0038 TP=0.0001	2 sites	TN=0.0077 TP=0.0002	3 sites	TN=0.0114 TP=0.0003

Undeveloped Area BMPs

The following chart projects practices that could be implemented over time for undeveloped areas of land and municipal purposes such as a storm water management program. Load reductions are not calculated due to unknown factors such as acreage and land use type. However, the number of projects and type of practices are estimated in order to give planners an economic estimate which will be provided in the following section.

BMP	1-3 Years		4-7 Years		8-10 Years	
	Number	Practices	Number	Practices	Number	Practices
LID Practices	5 sites	Bio swales Bioretention Xeriscaping, etc.	5 sites	Bio swales Bioretention Xeriscaping, etc.	5 sites	Bio swales Bioretention Xeriscaping, etc.
Greenways Parks	5 acres	Land acquisition Trail Building Maintenance	10 acres	Land acquisition Trail Building Maintenance	15 acres	Land acquisition Trail Building Maintenance
Community Gardens	1 sites	Land acquisition Structural BMPs	1 sites	Land acquisition Structural BMPs	1 sites	Land acquisition Structural BMPs
Agricultural BMPs	2 sites	Pasture/Grazing Management	2 sites	Pasture/Grazing Management	2 sites	Pasture/Grazing Management

Water Quality Issues and Concerns

On October 22, 2009 a public stakeholder meeting (sponsored and facilitated by BCWIG and the University of Missouri Extension) was held to discuss water quality issues and concerns for the Town Branch watershed. The purpose of this meeting was to identify and prioritize a list of concerns that would help give guidance for the community in implementing water quality practices and programs for deterring water quality threats. Further meetings were held to finalize action measures and Best Management Practices (BMPs) that would be applicable to implement throughout the Town Branch watershed. Though these action measures and BMPs will be discussed later, it is important to note that this is a guide. While some of these issues are currently being addressed, it may take many years for other issues to be addressed. However the first step is to identify the concerns and needs of the citizens in order to protect water quality.

Water Quality Issues and Concerns of Town Branch
Stakeholder Meeting (October 22, 2009)

Issue	Concerns/Needs
Future Development	1. Planning for future growth. 2. Having a reliable storm water infrastructure system. 3. Increase amount of public space and establish greenway system.
Storm Water Infrastructure	1. Need for better sediment and erosion control. 2. Need for disconnecting impervious areas. 3. Need for increasing infiltration through open spaces. 4. Need for detaining and retaining storm water. 5. Need for creating stream buffer zones and setbacks.
Waste Water Infrastructure	1. Deter infiltration of storm water runoff into sanitary sewers. 2. Convert on-site waste water systems to sanitary sewer system.
Homeowner/Commercial Influences	1. Deter over-fertilization of lawns. 2. Need for better landscape design and planning to capture runoff. 3. Need to enlighten citizens about the importance of water quality.
Town Branch Attributes	1. Streambanks are in poor condition and have a lack of vegetation. 2. Need to address trash, debris and environmental health concerns. 3. Need to incorporate flood control with water quality.
Water Conservation	1. Educate landowners about lawn watering practices. 2. Have an emergency water conservation plan during droughts.
Agricultural Operations	1. Recognize the need, diversity and benefits of agricultural land uses. 2. Promote agricultural BMPs and related cost-share programs. 3. Promote urban agricultural garden operations/markets.

Action Measures

In order to address and achieve the load reductions calculated in the before mentioned TMDL, certain management measures will have to be implemented over time. These management measures include implementing best management practices as well as developing an outreach strategy.

Best Management Practices

Best management practices (BMPs) are structural and non-structural components and procedures that can be implemented throughout a watershed to deter the impacts from non-point source pollution. In order to the preserve the natural water quality of the Town Branch watershed, BMPs need to become general knowledge and applied through education, voluntary adoption and technical oversight.

Structural BMPs include practices that are implemented on the land such as the construction of storm water controls (forebay-detention basins, grassed swales, bio-retention cells, rain gardens, etc.), establishing riparian corridors/buffers and the utilization of advancing technological systems (water/oil separators, permeable pavement, centrifugal sediment separators, etc.).

Non-structural BMPs focus on non-physical practices such as education, planning, zoning and community development. These methods are typically less costly than structural practices. Examples include ordinances designed to preserve open space or create stream buffer setbacks as well as cost-share programs that help landowners implement structural BMPs.

As previously stated, several of the issues identified at the stakeholder meeting are currently being implemented. However, other practices and/or programs will have to be researched for local applicability, funding resources and general acceptance.

A detailed breakdown of these action measures are listed in the following tables. The tables include estimates of the amounts of technical and financial assistance needed for implementation, associated cost, and sources of potential cooperators. Information in this table also summarizes a timeline of the achieving these goals. The definitions for the timeline or milestones are broken down into the following:

Category of Goals	Definition	Timeframe
Ongoing Process	Projects currently being researched funded or implemented by designated cooperators.	Current/Perpetual
Short-Term Goal	Feasible projects that could be implemented through grants and current available technical resources.	1-3 years
Mid-Term Goal	Projects that will require more planning but may be implemented through grants and other funds.	4-7 years
Long-Term Goal	Projects that will require detailed planning, monitoring/evaluation and a specific source of funding.	8 years or more

1. **Future Development**				
Practice	Financial Estimate & Assistance	Cooperators	Comments	Schedule Milestones
Establishment of a comprehensive plan for the city of Bolivar.	Planning phase is currently funded.	City of Bolivar, Community Partners	Currently being implemented. Expected completion date is in 2012.	Ongoing Process
Upgrading and maintaining the storm water infrastructure system.	>$1,000,000 Funding options are currently being researched.	City of Bolivar, BCWIG, Community Partners	Bolivar will be complying with the NPDES requirements since its population exceeded 10,000 residents in 2010. It can be expected that this planning and implementation process will take a while before the program is established.	Long-Term Goal & Ongoing Process
Increase the amount of open space and establish a greenway trail system.	$250,000+ Funding options are currently being researched.	City of Bolivar, Community Partners	Though a long term goal, this can be a part of the comprehensive plan for the city of Bolivar. Greenway trail systems are typically sited in floodplain areas which are susceptible to flooding. They not only provide recreational, health and alternative transportation benefits, but also help in protecting water quantity and quality conditions.	Long-Term Goal

New Development

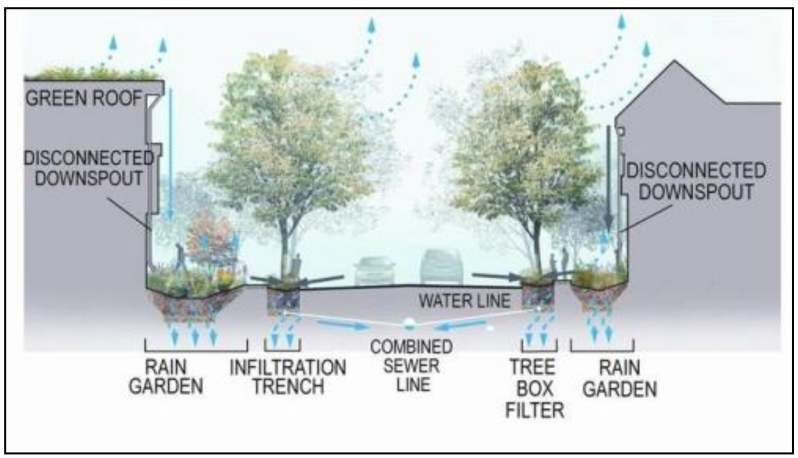
Greenway Corridor

2. Storm Water Infrastructure				
Practice	Financial Estimate & Assistance	Cooperators	Comments	Schedule Milestones
Establish a Storm Water Steering Committee	$500 Minimal assistance needed.	City of Bolivar and Community Groups	Due to the City of Bolivar complying with NPDES requirements to address storm water runoff -a local storm water steering committee should be organized to research, develop and evaluate options for establishing, maintaining and funding a storm water management program.	Short-Term Goal & Ongoing Process
Implement Storm Water Program	$100,000 per year Funding options are currently being researched.	City of Bolivar, Storm Water Steering Committee, Community Groups (*Homebuilder's Association*, *Downtown Association,*	Through the NPDES process, certain ordinances may have to be implemented in order to address storm water runoff.	Long-Term Goal & Ongoing Process
Promote the disconnection of impervious area	Cost explained in following sections Funding options are currently being researched.	City of Bolivar and BCWIG	These methods promote the establishment of grassed buffers, swales, bio-retention cells and open space between areas of impervious areas (such as parking lots, concrete drainage ways, etc.). These practices will be explained in the further section.	Mid-Term Goal
Upgrade and maintain storm water facilities.	$100,000 per year Funding options are currently being researched.	City of Bolivar	Storm water facilities such as detention basins, inlet/outlets, drainage ways and other BMPs will need to be established, upgraded and maintained in order to sustain their effectiveness.	Long-Term Goal & Ongoing Process
Promote the establishment of a city-wide Hazardous Household Recycling Program	$25,000 Funding options are currently being researched.	City of Bolivar, Polk County, Polk County Health Department, BCWIG and Community Groups	The establishment of a hazardous household recycling program will help citizens to properly dispose of	Mid-Term Goal

3. **Waste Water Infrastructure**				
Practice	Financial Estimate & Assistance	Cooperators	Comments	Schedule Milestones
Continue to comply with the NPDES permit and policy.	Funding is currently being provided by the City of Bolivar for such compliance.	City of Bolivar	The City of Bolivar continues to comply with NPDES policy and intends to upgrade its facility by installing a disinfection system and any other future requirements.	Ongoing Process
Convert and decommission existing residential on-site wastewater systems (septic tanks) to the municipal waste water system.	$1,200 per site Includes connection fee-decommission of system.	City of Bolivar, Polk County Health Department	Converting on-site waste water residences to the municipal system will ensure that waste water treatment is more centralized and manageable.	Short-Term Goal & Ongoing Process
On-site wastewater system maintenance and rehabilitation	(Per System) $3,000 for rehabilitation $120 for maintenance Potential Grants	Polk County and Polk County Health Department	Because of the treatment inefficiencies of certain older or improperly installed systems, rehabilitation can be a costly expenditure. Also facilitating the maintenance (clean-outs) of systems through cost-share program is an efficient way for educating homeowners about their systems.	Short-Term Goal

The Bolivar Municipal Waste Water Treatment facility is a permitted NPDES site that treats waste water before releasing its effluent into Town Branch. The city performs monthly water quality tests on Town Branch as part of its NPDES requirement. It also maintains and performs upgrades to its treatment and collection systems on a continual basis in order to ensure infrastructural reliability. The treated effluent that is released from this facility complies with the all requirements and water quality standards as set forth through the Missouri Department of Natural Resources.

4. **Residential/Commercial BMPs**				
Practice	Financial Estimate & Assistance	Cooperators	Comments	Schedule Milestones
Promote Low Impact Development (LID) design techniques	$250,000 Potential grants	BCWIG, City of Bolivar, NRCS	This method incorporates different practices such as bioswales, rain gardens, bioretention cells, pervious pavements, level spreading, etc.	Short-Term Goal On-going Process
Promote proper lawn fertilization techniques	$5,000 Potential grants	BCWIG, NRCS	This method was designed to provide landowners the proper guidance in fertilizing and caring for their yard by calculating the exact nutrient and fertilizer requirements in the form a conservation plan.	Short-Term Goal On-going Process
Promote rainwater detention use	$5,000 Potential grants	BCWIG, City of Bolivar, NRCS	Rainwater can be detained for future use (such as watering, irrigation and fire protection) through many different practices such as rain barrels, cisterns and underground tanks.	Short-Term Goal On-going Process



Low-Impact Development Example


Rain Garden

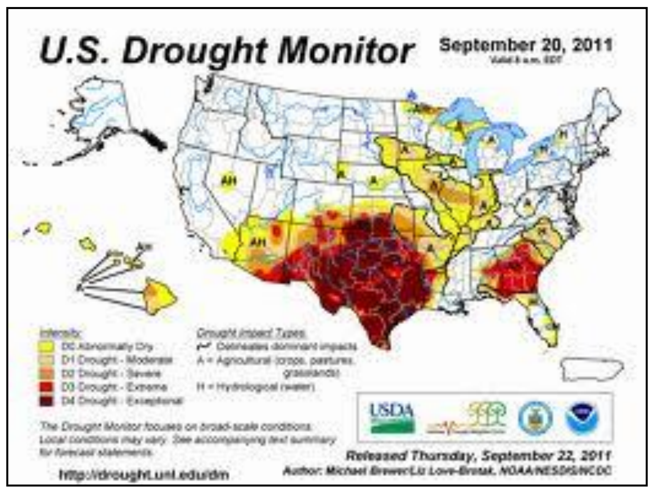
5. **Town Branch Attributes**				
Practice	Financial Estimate & Assistance	Cooperators	Comments	Schedule Milestones
Promote stream restoration practices and projects.	$100,000 Potential grants	BCWIG, City of Bolivar, NRCS, Missouri Department of Conservation	There are various methods of restoring degraded, incised and eroded streams. This may include incorporating hard armoring - practices with natural vegetative techniques.	Short-Term Goal Mid-Term Goal
Promote trash and debris deterrence methods.	$10,000 Potential grants	BCWIG, City of Bolivar, Polk County	Trash and debris flow is a major issue in protecting waterways. There are many structural and non-structural BMPs that could be employed to deter such pollution. Examples include holding community stream clean-ups, advocating current and future recycling programs and promoting new inlet protection and maintenance practices.	Short-Term Goal
Incorporate water quality control measures with flood control practices such as detention basins.	$50,000 Potential grants	BCWIG, City of Bolivar, NRCS	This would tie in with previous recommended practices such as Low Impact Development practices as well as the City of Bolivar's Stormwater Management program. Though detention basins are designed for flood control, they could easily be designed for water quality control as well.	Mid-Term Goal

Restored Stream

Water Quality Detention Basin

6. **Water Conservation**				
Practice	Financial Estimate & Assistance	Cooperators	Comments	Schedule Milestones
Education programs for landowners regarding watering practices.	Potential grants	BCWIG, City of Bolivar, NRCS, University Extension	Water conservation in association with lawn care management has become a nationwide issue. The most effective way to promote proper watering is through educational programs.	Short-Term Goal Mid-Term Goal
Emergency Water Conservation Plan	Potential grants	BCWIG, City of Bolivar, Polk County	Due to the potential threat of water quantity shortages, the Missouri Department of Natural Resources encourages communities to have a contingency plan in order to sustain local economic and environmental resources.	Short-Term Goal

Rain Barrel



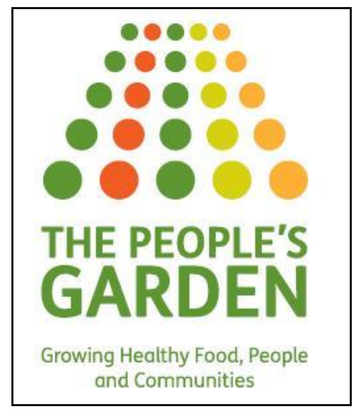
USDA Drought Monitoring System

Watering Practices

7. **Agricultural Land Uses and Practices**				
Practice	Financial Estimate & Assistance	Cooperators	Comments	Schedule Milestones
Promote agricultural BMPs and cost-share assistance programs.	$100,000 Federal and state cost-share assistance programs	NRCS, Polk County SWCD	The Natural Resources Conservation Service and the Polk County Soil and Water Conservation District provide technical assistance and cost-share programs to agriculture operators who are looking to improve and sustain the environmental and economic resources of their operations. This would be more applicable for landowners in the Piper Creek watershed since agricultural operations are somewhat limited in the Town Branch watershed.	Mid-Term Goal & On-going Process
Promote urban gardens and farmers markets.	$5,000 Potential grants	University Extension, NRCS, Polk County SWCD, Community Groups	Locally-led food production initiatives have increased throughout the United States, specifically in urban areas where agriculture production is somewhat limited due to space. Through local groups, the potential for establishing community gardens and private nurseries/orchards to support the Farmer's Market is an option.	Short-Term Goal

Managed Grazing System

Community Garden



USDA Program

Bolivar Community
Watershed Improvement Group

Outreach Program & Strategy

Education and outreach activities are designed to inform the public on BMPs and conditions that relate directly to improvement of water quality within the watershed. Many avenues for outreach are available to residents of the watershed. Organizations such as the Environmental Protection Agency, Natural Resources Conservation Service, Soil and Water Districts, Missouri Department of Conservation, University of Missouri Extension, City of Bolivar and the Polk County Health Department provide much needed information to landowners regarding BMPs and give technical advice on practices or services that will benefit the land and water quality in the watershed.

Most importantly, the Bolivar Watershed Improvement Group is an excellent organization that works with these groups to implement watershed protection projects and goals. Being a non-profit organization, BCWIG is the natural organization to facilitate the work between agencies and residents of the watershed. For the past five years, BCWIG has facilitated projects and sponsored events to protect water quality in the Piper Creek and Town Branch watershed. Their organizational and economic sustainability is integral for further protecting this watershed.

All available avenues for providing education and outreach will continue be evaluated to ensure as many landowners within the watershed have access to good and pertinent information to make logical and informed decisions regarding their activities that may affect water quality. The following table shows some identified educational opportunities that will be used to improve water quality education in the watershed.

Education Opportunities					
Education Project/Goal	Financial Estimate Assistance	Cooperators	Comments	Schedule Milestones	Monitoring Evaluation
BCWIG Coordination	\$100,000 per year Potential Grants Local Support	City of Bolivar, Polk County, University Extension, NRCS, Polk County SWCD, Community Groups	The economic and organizational sustainability of BCWIG is imperative. In order to be more effective, an executive director position should be created to oversee and direct any future projects.	Short-Term Goal Have a position created by 2013	Number grants, and projects being implemented.
Water Quality Newsletter & Website	\$1,000 per year Through BCWIG services	City of Bolivar, Polk County, University Extension, NRCS, Polk County SWCD, Community Groups	Publishing a newsletter and hosting website dedicated to local water quality issues is an effective way to outreach to the community.	Short-Term Goal	Number of respondents and hits.
Public Awareness Campaign	\$1,000 per year Through BCWIG services	BCWIG, local cooperators	This would include participating in local community events where expenditures would cover booth rental space, brochures, flyers and signs.	Short-Term Goal	Number of events and number of brochures distributed.

Education Opportunities *(continued)*					
Education Project/Goal	Financial Estimate Assistance	Cooperators	Comments	Schedule Milestones	Monitoring Evaluation
Educational Workshops	$2,000 per year Potential grants	BCWIG City of Bolivar, Polk County, University Extension, NRCS, Polk County SWCD, Community Groups	Many educational workshops could be implemented that focus a wide arrange of issues as explained in the BMP section	Short-Term Goal Four a year	Based on number of participants.
Public Service Announcements	$1,000 per year Through BCWIG services	BCWIG City of Bolivar, Polk County, University Extension, NRCS, Polk County SWCD, Community Groups	In order to facilitate workshops and other events, public service announcement would provide a good avenue to disseminate information out to the public.	Short-Term Goal	Based on number of responses.
Polk County Watershed Festival	$2,000 per year Potential grants	BCWIG City of Bolivar, Polk County, University Extension, NRCS, Polk County SWCD, Community Groups	Watershed festivals are an effective way of enlightening school children about water quality issues. Local schools are typically open to participating in such events.	Short-Term Goal One a year	Based on number of participants.

Watershed Festival

Educational Workshop

Monitoring Program & Strategy

Continued monitoring of the Town Branch/Piper Creek watershed will be integral in better understanding the dynamics of this watershed as well as evaluating the effectiveness of implemented action measures. It has been determined from existing evaluations and studies that there is general lack of water quality information in this watershed. A specific monitoring program will help to further define action measures and management strategies.

Currently, BCWIG and the Polk County Health Department monitor Town Branch through the Stream Team program. However, it has been determined by the Monitoring Committee of BCWIG that monitoring should be expanded and focused on two areas: TMDL studies and bacteria source tracking.

TMDL & BMP Monitoring

Since the TMDL addresses Total Phosphorous, Total Nitrogen and Total Suspended Solids; it will be imperative to monitor for these constituents. The information generated will help cooperators to further delineate and address the sources contributing to nonpoint pollution. Monitoring for these constituents will also be complementary to the city of Bolivar's stormwater management program. Most importantly, a TMDL monitoring program will also help to cooperators evaluate the effectiveness of implemented best management practices.

Bacteria Source Tracking

Bacteria source tracking is a method that identifies and delineates certain signatures of fecal coliform in order to determine its source whether is originates from human, bovine, equine or other mammalian sources. This is very useful in watershed studies that have mixed urban and agricultural land uses. By further defining the nonpoint source, it is very useful in helping resource managers in addressing the particular source identified. Bacteria source tracking

Monitoring Program				
Monitoring Project	Constituents Outputs	Cooperators	Schedule	Cost Financial Assistance
TMDL	Total Phosphorus, Total Nitrogen and Total Suspended Solids. Modeling and report	BCWIG, City of Bolivar, Polk County Health Department, Missouri State University	1. One year of monthly sampling. 2. Annual sampling every five years.	$30,000 for first year
Bacteria Source Tracking	*E. coli* isolates and signatures. Report	BCWIG, Polk County, Polk County Health Department, Missouri State University	1. One year of monthly sampling. 2. Targeted sampling when needed.	$15,000 for first year

Contracted Services

In order to implement a qualified monitoring program, services will have to be contracted for laboratory analysis, sampling and/or modeling. Private institutions and public universities provide such services. With this, a Quality Assurance Project Plan (QAPP) will have to be written and approved.

Funding Estimates

The following chart is an estimate of costs to implement the watershed management plan. The numbers should be viewed as minimal and are subject to change.

Program/Timeframe	1-3 Years	4-7 Years	8-10 Years	Total
Riparian BMPs	$ 26,600	$49,000	$37,400	$113,000
Residential BMPs	$12,000	$21,000	$23,000	$56,000
Urban BMPs	$32,500	$65,000	$85,000	$182,500
Future BMPs for Undeveloped Areas	$35,000	$60,000	$85,000	$180,000
Education/Outreach Administration*	$171,000	$180,000	$189,000	$540,000
Monitoring Evaluation	$45,000	$20,000	$20,000	$85,000
Total	$322,100	$395,000	439,400	$1,156,500

** Includes watershed management staff position*

Funding Options

In order to fund such operations, a financial strategy will have to be devised. This will include a diversity of options such as attaining grants and soliciting donations. Such grant opportunities include:

- Clean Water Act 319 Non-point source pollution grants (MO Dept. of Natural Resources/EPA)
- Urban Waters Small Grants (EPA-Office of Water)
- Targeted Watershed Grants Program (EPA)
- Urban and Community Forestry Challenge Cost Share Grants (U.S. Forest Service)
- Environmental Educational Grants Program (EPA)
- People's Garden Community Grant Program (U.S. Dept. of Agriculture)
- Community Foundation of the Ozarks

Appendix A

Total Maximum Daily Load for Total Suspended Solids, Total Nitrogen and Total Phosphorus

United States Environmental Protection Agency

Region 7

Total Maximum Daily Load

For Total Suspended Solids,

Total Nitrogen and Total Phosphorus

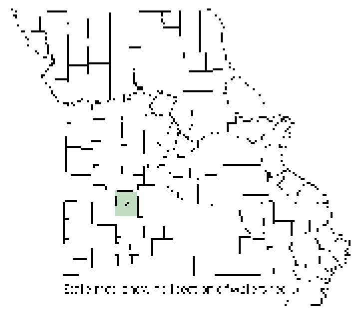
Piper Creek (MO_1444)

Polk County, Missouri

for Karen A Flournoy
William A. Spratlin
Director
Water, Wetlands and Pesticides Division

11-1-10
Date

Total Maximum Daily Load (TMDL)
For Piper Creek (Town Branch)
303(d) Listed Pollutants: Organic Sediment and Unknown



Name: Piper Creek (Town Branch)[1]

Location: Near the city of Bolivar in Polk County, Missouri

Hydrologic Unit Code (HUC): 10290107-0303

Water Body Identification (WBID): 1444[2]

Missouri Stream Class: Class P[3]

Designated Beneficial Uses:
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Human Health Protection (Fish Consumption)
- Whole Body Contact Recreation – Category B (CSR, 2009)

Size of Classified Segment: 7.5 miles

Size of Impaired Segment: 7.5 miles

Location of Classified Segment: From State Highway 83 in Bolivar, Missouri, to the confluence of Piper Creek with the Pomme De Terre River (approximately from 93º 24' 16.93" West, 37º 36' 1.45" North to 93º 24' 18.16" West, 37º 40' 45.36" North).

Location of Impaired Segment: From State Highway 83 in Bolivar, Missouri, to the confluence of Piper Creek with the Pomme De Terre River (approximately from 93º 24' 16.93" West, 37º 36' 1.45" North to 93º 24' 18.16" West, 37º 40' 45.36" North).

Impaired Use: Protection of Warm Water Aquatic Life

Pollutants: Organic Sediment and Unknown

Identified Source on 303(d) List: City of Bolivar Wastewater Treatment Facility (WWTF)[4] and Unknown

TMDL Priority Ranking: High

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[1] The water body is named "Town Branch" in Missouri water quality standards (WQS) Table H (10 Code of State Regulations (CSR) 20-7.031) and referred to as Piper Creek (Town Branch) in the 2008 303(d) List.
[2] WBIDs are usually assigned to one segment of a classified stream; however, WBID #1444 includes Town Branch as well as a segment of Piper Creek. Town Branch is the receiving stream for Bolivar WWTF and is a tributary of Piper Creek. Throughout this TMDL, the name Piper Creek will be used.
[3] Streams that maintain permanent flow even in drought periods. See Missouri WQS 10 CSR 20-7.031 (1)(F).
[4] Missouri State Operating Permit No. MO0022373. The state permitting system is Missouri's program for administering the National Pollutant Discharge Elimination System (NPDES) program.

List of Acronyms (continued)

MSOPS	Missouri State Operating Permitting System
NA	Not Applicable
NASS	National Agricultural Statistics Service
NBOD	Nitrogenous Biochemical Oxygen Demand
NH_3-N	Ammonia Nitrogen
NO_2-N	Nitrite Nitrogen
NO_3-N	Nitrate Nitrogen
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
O&G	Oil and Grease
°C	Temperature in Degrees Celsius
PBIAS	Percent Bias Statistic
PCS	Permit Compliance System
RMSE	Root Mean Square Error Statistic
SDI	Shannon Diversity Index
SOD	Sediment Oxygen Demand
SWPPP	Storm Water Pollution Prevention Plan
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TR	Taxa Richness
TRC	Total Residual Chlorine
TROP	Total Recoverable Oil Petroleum
TSS	Total Suspended Solids
URS	URS Group Inc.
U.S.	United States
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
VSS	Volatile Suspended Solids
WBID	Water Body Identification
WET	Whole Effluent Toxicity
WLA	Wasteload Allocation
WQS	Water Quality Standards
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

The Piper Creek Total Maximum Daily Load (TMDL) is being established in accordance with Section 303(d) of the Clean Water Act (CWA). The water quality limited segment is included on the United States (U.S.) Environmental Protection Agency (EPA) approved Missouri 2008 303(d) List and is identified as impaired due to organic sediment and unknown pollutants. This report addresses the Piper Creek impairment by establishing total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP) TMDLs in accordance with Section 303(d) of the CWA. EPA is establishing this TMDL to meet the milestones of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001.

During 2003-2004, the Missouri Department of Natural Resources (MDNR) conducted a water quality study aimed at assessing macroinvertebrate populations and characterizing biochemical oxygen demand (BOD), TSS and volatile suspended solids (VSS) concentrations in portions of Town Branch (a tributary to Piper Creek) and Piper Creek. The objective of this study was to determine if the macroinvertebrate community and water quality of Town Branch and Piper Creek were being affected by a wastewater discharge (city of Bolivar wastewater treatment facility (WWTF)). This study was followed by a second study in 2005 in which additional sediment and organic solids assessment in Town Branch and Piper Creek were performed. These studies concluded that both point and nonpoint sources contribute to impaired aquatic life conditions in these water bodies.

Section 303(d) of the CWA and Federal Chapter 40 of Code of Federal Regulations (CFR) Part 130 requires states to develop TMDLs for waters not meeting designated beneficial uses under technology-based controls for pollutants of concern. The TMDL process quantitatively assesses the impairment factors so that states can establish water-quality based controls to reduce pollutants and restore and protect the quality of their water resources. The purpose of a TMDL is to determine the maximum amount of a pollutant (the load) that a water body can assimilate without exceeding the water quality standards (WQS) for that pollutant. WQS are benchmarks used to assess the quality of rivers and lakes. The TMDL also establishes the pollutant loading capacity (LC) necessary to meet the Missouri WQS established for each water body based on the relationship between pollutant sources and in-stream water quality conditions. The TMDL consists of a wasteload allocation (WLA), a load allocation (LA) and a margin of safety (MOS). The WLA is the portion of the allowable load that is allocated to point sources. The LA is the portion of the allowable load that is allocated to nonpoint sources. The MOS accounts for the uncertainty associated with linking pollutant load to the water quality impairment. This is often associated with model assumptions and data limitations.

The goal of the TMDL program is to restore impaired designated beneficial uses to water bodies. Thus, reduction strategies for point and nonpoint sources and implementation of source controls throughout the watershed will be necessary to restore the protection of warm water aquatic life use in Piper Creek. In addition to establishing a TMDL for Piper Creek, this report provides a summary of information, results and recommendations related to the impairment based on a broad analysis of watershed information and detailed analysis of water quality, flow data and comparison to a reference stream condition in the same ecoregion or ecological drainage unit (EDU) in which Piper Creek is located.

Section 2 of this report provides background information on the Piper Creek watershed and Section 3 describes the water quality problems. Section 4 describes potential sources of concern and Section 5 presents the applicable WQS. Section 6 describes the modeling and technical approach used to develop the TMDL. Sections 7 to 11 present the LC, WLA, LA, MOS and seasonal variation. Sections 12 to 14 present the follow-up monitoring plan, reasonable assurances and public participation. A summary of the administrative record is presented in Section 15. Appendix A summarizes the available water quality data. Appendix B presents QUAL2K modeling conducted to support this TMDL. Methods and data used in the load duration curve (LDC) modeling are presented in Appendix C – Appendix E.

2 BACKGROUND

This section of the report provides information on Piper Creek and its watershed.

2.1 The Setting

Town Branch and Piper Creek are located in Polk County within the Middle Pomme de Terre River watershed in southwest Missouri. Town Branch flows northeast through the city of Bolivar into Piper Creek. Piper Creek then flows northwest into Pomme de Terre River, which is part of the Osage River Basin that flows into the Missouri River. The Piper Creek impaired watershed covers an area of approximately 37 square miles with a combined stream distance of approximately eight miles.

Portions of Piper Creek and Town Branch are listed as impaired due to exceedances of Missouri's general water quality criteria for protection of warm water aquatic life and natural biological aquatic communities. Both streams were placed on the 303(d) list under the name "Piper Creek" due to observations of objectionable solids downstream of the city of Bolivar WWTF. Piper Creek remains as an impaired water body on the consolidated 2008 Missouri 303(d) List due to organic sediments and unknown pollutants and sources.

The EPA-approved 2008 303(d) List of impaired waters identifies the impaired segments of Piper Creek (Town Branch) at a length of 7.5 miles. Due to the increased accuracy of Geographic Information System (GIS) data layers for analysis over previous methods of stream length measurements, the stream length used in the TMDL analysis does not correspond exactly to the length shown in the 2008 303(d) List. The descriptive start and end point of each segment remains the same. This TMDL addresses the impaired segment in its entirety. Based on such improved estimates using GIS, the impaired segment is approximately eight miles in length, originating on Town Branch at Highway 83 and continuing northeast to the confluence of Piper Creek and the Pomme de Terre River (Figure 1). The elevation of the watershed ranges from approximately 1260 to 870 feet (USDI, 1997). The channel averages approximately 21.5 feet wide based on measurements at four monitoring locations and the average stream gradient is 0.004 feet/feet or 0.4 percent.

2.2 Physiographic Location, Geology and Soils

The Piper Creek watershed is located within the Springfield Plateau, a region within the Ozark Natural Division. The Ozark Natural Division is a physiographic section of the Ozark Highland Province. The geology of the watershed is dominated by Jefferson City-Cotter dolomite and includes a small area of Mississippian limestone. Movement of water from the surface to subsurface is minimal throughout most of the watershed. This is due to the stony red clay residue overlying much of the Jefferson City-Cotter and the presence of thin shale units within the formation (MDC, 2009).

Table 1 and Figure 2 provide a summary of soil types in the impaired Piper Creek watershed. Soil data for the Piper Creek watershed is from Natural Resources Conservation Service (2009) soil maps and data. The upland soils along Piper Creek are primarily of the Hoberg-Bona-Creldon Association with a slope range of 1 to 15 percent. The Hoberg silt loam is gently sloping (2 to 5 percent), very deep, well-drained soil found on summits and shoulder slopes, with a fragipan layer. The Bona gravelly silt loam has similar characteristics to the Hoberg, but it can be strongly sloping (3 to 15 percent) and is also found on back slopes. The Creldon silt loam also has similar characteristics, but it is nearly level and is found on summits only. The bottom-land soil is the Sturkie-Moniteau-Horsecreek Association, with a slope of 0 to 2 percent built from alluvium. The Sturkie silt loam is found in the flood plain. This very deep, nearly level soil is well drained with moderate permeability and is frequently flooded. Horsecreek silt loam has the same characteristics, but is found on the stream terrace. Moniteau silt loam is similar to Horsecreek, but is poorly drained and has moderately slow permeability. Lower Piper Creek runs through the Viraton-Ocie-Gatewood soil association. This association is found on ridges and hills with a slope range of 2 to 35 percent. These silt loams are deep and moderately well drained.

The soils hydrologic group relates to the rate at which surface water enters the soil profile, which in turn affects the amount of water that enters the stream as direct runoff. The dominant soil type C, covers approximately 73 percent of the watershed. Group C includes sandy clay loam soils that have a moderately fine to fine structure. These soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water. Soil type B covers approximately 18 percent of the Piper Creek watershed. Group B includes silt loam and loam which have moderate infiltration rates. These soils consist of well drained soils with moderately fine to moderately coarse textures. Approximately 5 percent of soils in the impaired watershed are categorized as Group D. Group D soils include clay loam, silty clay loam, sandy clay, silty clay or clay. This soil group has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material (Purdue Research Foundation, 2009).

2.3 Rainfall and Climate

Two weather stations are within or close to the Piper Creek watershed (Figure 3). Both stations record daily precipitation, maximum and minimum temperature, snowfall and snow depth. Figure 3 provides a summary of rainfall and climate data for Station 230789 (Bolivar 1

NE, Missouri) based on 30-year totals (1971 – 2000) (NOAA, 2009). The annual average precipitation and temperature over the 30-year period is 45.5 inches and 55.5 degrees Fahrenheit, respectively. These nearby weather stations will provide useful information for simulating stream temperature which impacts the growth of algae, decay of carbonaceous biochemical oxygen demand (CBOD), transformations of nutrients and solubility of dissolved oxygen (DO).

Table 1. Piper Creek Watershed Soils Breakdown (NRCS, 2009)

Soil Type	Hydrologic Soil Group	Acres	Percent
Bona gravelly silt loam	B	509	2%
Peridge silt loam	B	425	2%
Pomme silt loam	B	1,361	6%
Racket silt loam	B	1,484	6%
Sturkie silt loam	B	265	1%
Wanda silt loam	B	299	1%
(Subtotal B soil group)	**B**	**4,344**	**18%**
Alsup gravelly silt loam	C	587	2%
Barden silt loam	C	672	3%
Basehor fine sandy loam	C	395	2%
Bolivar loam	C	2,501	11%
Creldon silt loam	C	2,969	13%
Goodson gravelly silt loam	C	237	1%
Goss gravelly silt loam	C	377	2%
Hoberg silt loam	C	2,152	9%
Mano-Ocie complex	C	798	3%
Ocie-Gatewood complex	C	1,452	6%
Plato silt loam	C	610	3%
Viraton silt loam	C	4,587	19%
(Subtotal C soil group)	**C**	**17,337**	**73%**
Glensted silt loam	D	315	1%
Hartville silt loam	D	501	2%
Sacville silty clay loam	D	253	1%
(Subtotal D soil group)	**D**	**1,069**	**5%**
Other[5]	B/C/D	1,002	4%

[5] Other soil types that make up less than one percent of the total watershed area include: Alsup silt loam (C), Blueye-Moko complex (D), Bolivar fine sandy loam (C), Cedargap gravelly silt loam (B), Goodson silt loam (C), Goss very cobbly silt loam (C), Goss-Moko complex (C), Horsecreek silt loam (B), Humansville silt loam (B), Liberal silt loam (C), McGirk silt loam (D), Moko-Rock outcrop complex (D), Moniteau silt loam (C/D), Sowcoon silt loam (D) and Wilderness gravelly silt (C).

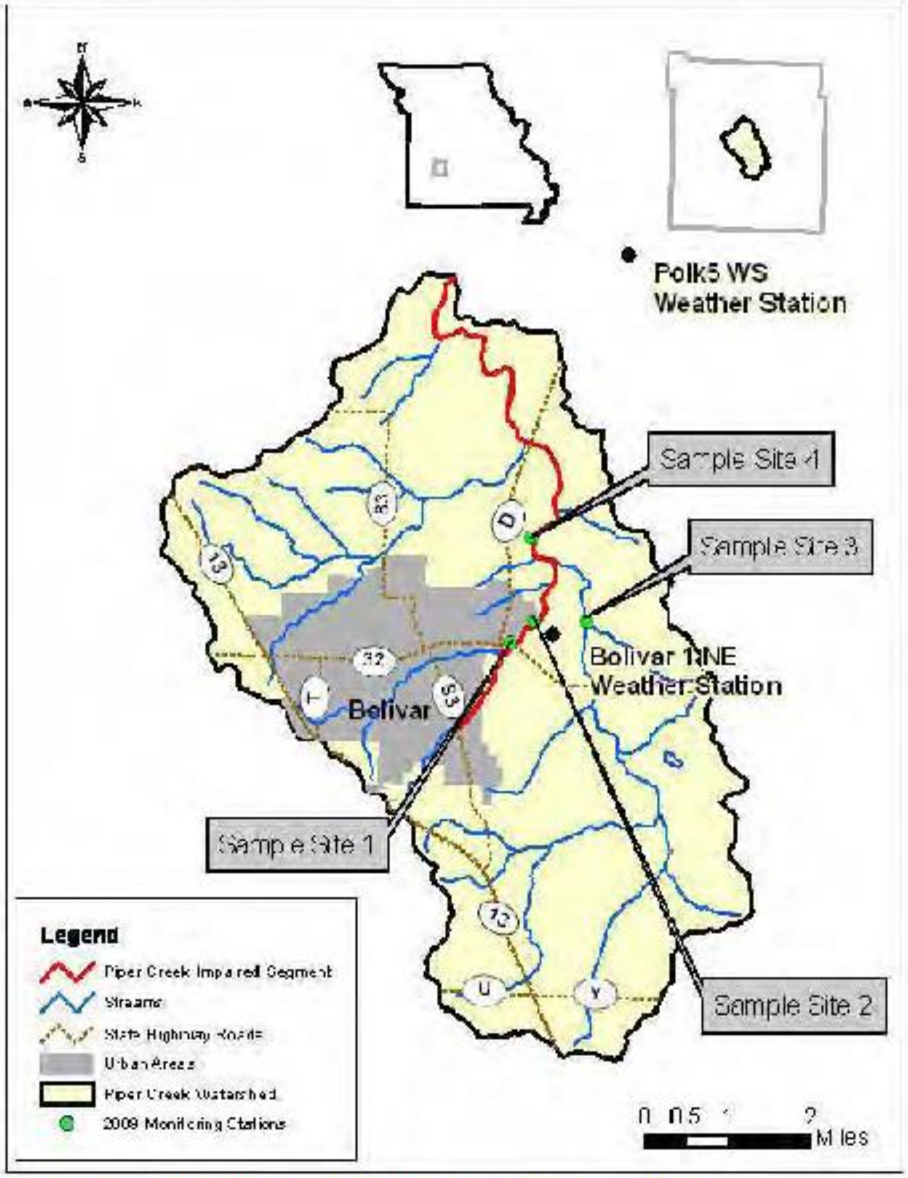

Figure 1. Location of Piper Creek Watershed with Weather Stations

5 *Piper Creek TMDL*

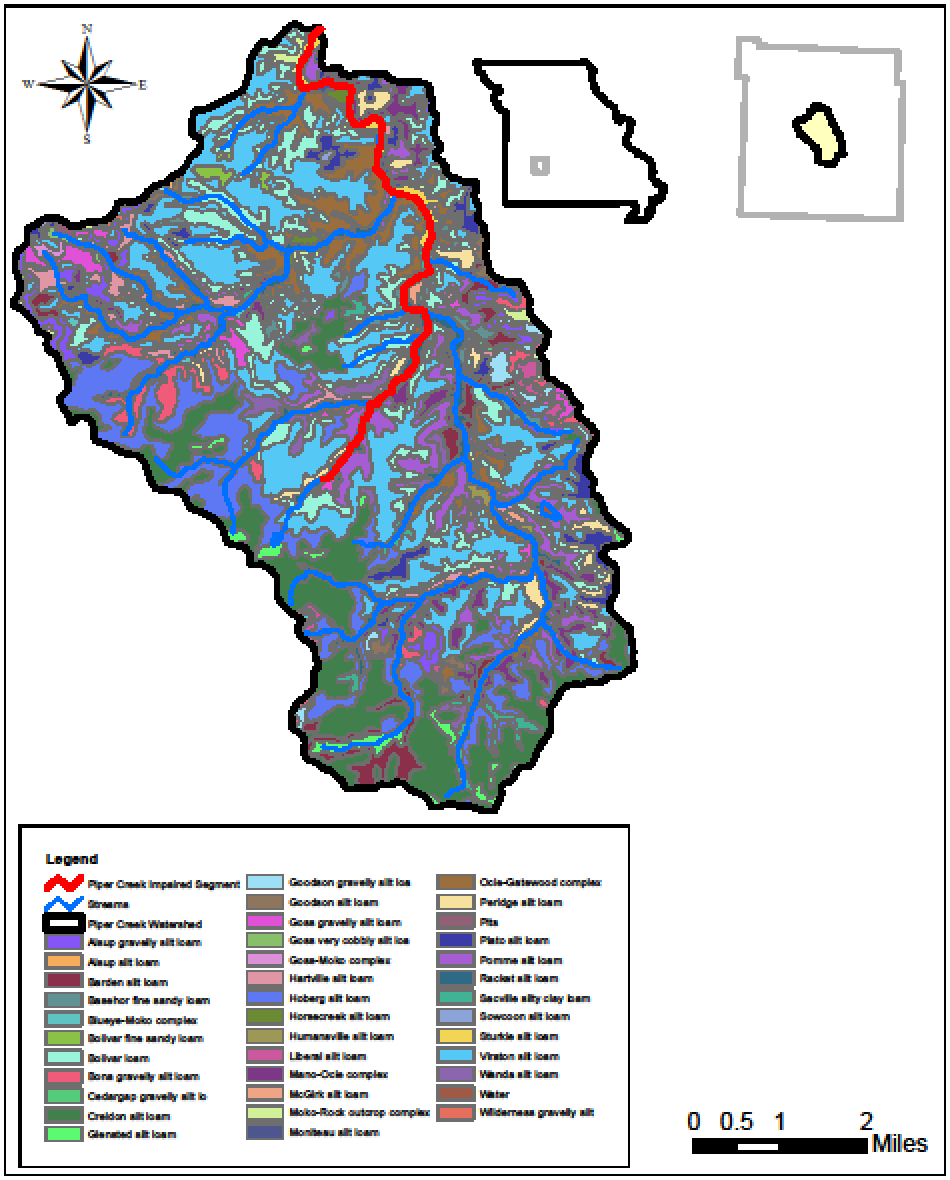

Figure 2. Piper Creek Watershed Soils

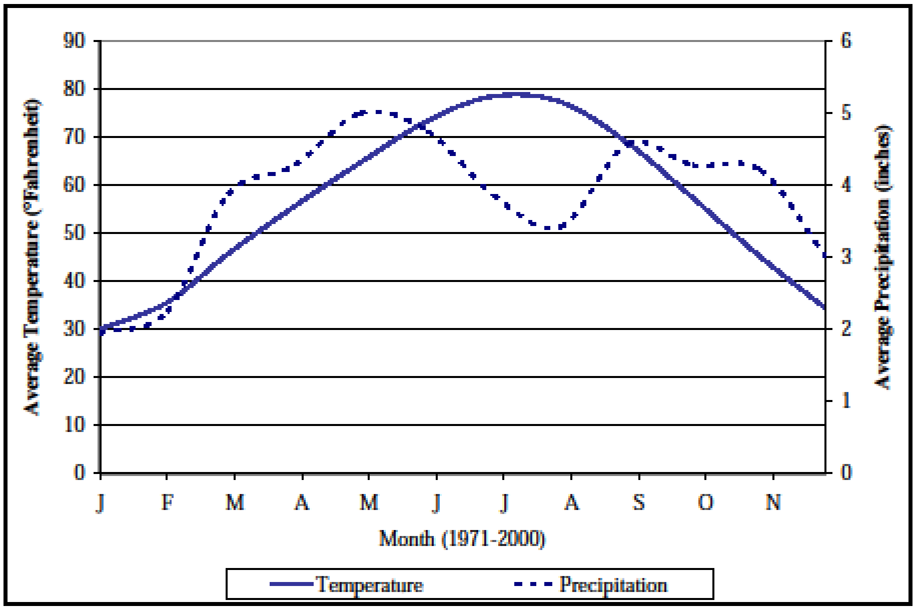

Figure 3. Thirty-Year Monthly Temperature and Precipitation Averages for Station 230789 (Bolivar, Missouri) (NOAA, 2009)

2.4 Population

According to the United States Census Bureau, the 2000 population for the city of Boliver was 9,143 (U.S. Census Bureau, 2000). The urban population of the watershed can be estimated by multiplying the percent of urban area (city of Bolivar) that is within the watershed and the individual population of the urban area. The urban population of the Piper Creek watershed is approximately 8,968.

The rural population of the watershed can be estimated based on the proportion of the watershed compared to Polk County. Polk County covers an area of 641.86 square miles and has a population of 26,992. The rural population in Polk County is approximately 15,218 (total county population minus population of Aldrich, Bolivar, Fair Play, Flemington, Halfway, Humansville, Morrisville and Pleasant Hope) and the rural county area is 630.33 square miles (total county area minus 11.53 square miles county urban area). The Piper Creek watershed rural area was estimated to be 758 persons; calculated by dividing the rural watershed area (31.4 square miles) by the Polk County rural area (630.33) and multiplying the product by the Polk County rural population (15,218 persons).

The total estimated population of the Piper Creek watershed is approximately 9,715. An overall population density for the Piper Creek watershed was calculated to be 263 persons per square mile (9,715 persons divided by 37 square miles).

2.5 Land Use and Land Cover

The land use and land cover of the Piper Creek watershed is shown in Figure 4 and summarized in Table 2 (MoRAP, 2005). The primary land uses/land covers are grassland (62.7 percent) and forest (12.6 percent) with impervious cover and low intensity urban areas occupying 7.1 percent and 6.7 percent of the watershed area, respectively. The remaining categories comprise less than seven percent of the watershed area.

Table 2. Land Use/Land Cover in the Piper Creek Impaired Watershed (MoRAP, 2005)

Land Use/Land Cover	Watershed Area		Percent of Watershed Area
	Acres	Square Miles	
Impervious[6]	1,682	2.6	7.1
High Intensity Urban[7]	91	0.1	0.4
Low Intensity Urban[8]	1,597	2.5	6.7
Barren or Sparsely Vegetated	171	0.3	0.7
Cropland	960	1.5	4.0
Grassland	14,887	23.3	62.7
Forest	2,993	4.7	12.6
Herbaceous[9]	1,214	1.9	5.1
Wetland	26	0.0	0.1
Open Water	130	0.2	0.6
Total	**23,751**	**37.1**	**100**

Note: MoRAP = Missouri Resource Assessment Partnership

[6] Impervious land use includes non-vegetated, impervious surfaces including areas dominated by streets, parking lots and buildings (MoRAP, 2005)
[7] High Intensity Urban land use includes vegetated urban environments with a high density of buildings (MoRAP, 2005).
[8] Low Intensity Urban land use includes vegetated urban environments with a low density of buildings (MoRAP 2005).
[9] Herbaceous land use includes open woodland and woody shrubland (including young woodland) with less than 60% vegetated cover (MoRAP 2005).

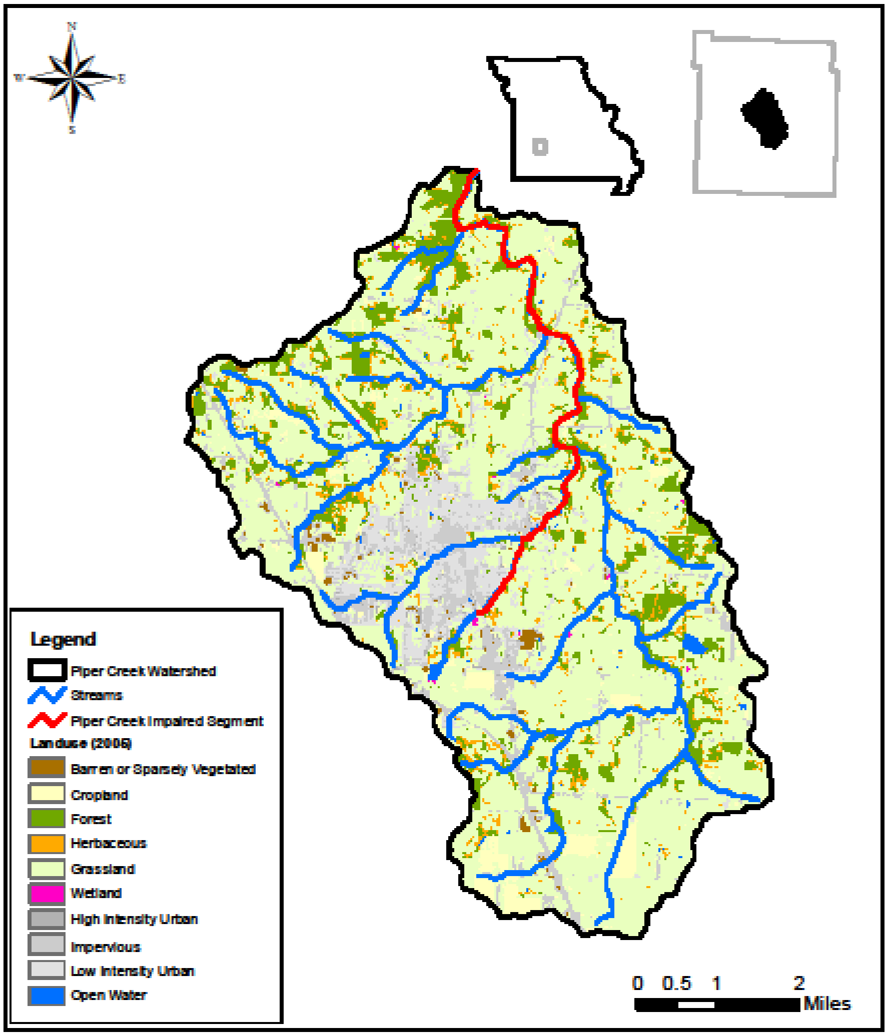

Figure 4. Land Use/Land Cover in the Piper Creek Impaired Watershed (MoRAP, 2005)

3 DEFINING THE PROBLEM

A TMDL is needed for Piper Creek because it is not meeting Missouri's general criteria pertaining to the protection of aquatic life (10 CSR 20-7.031). The stream was placed on the Missouri 303(d) List of impaired waters because it showed an accumulation of objectionable solids downstream from the Bolivar WWTF in 1993 (MDNR, 2005). A two-year study of the deposition of solids in Town Branch and Piper Creek was conducted by MDNR beginning in 2003. The portion of the study that characterized impacts related to sediment deposition and organic solids was completed in 2004. The results of this study do not indicate VSS impairment due to the treatment plant. However, the bioassessment portion of the study indicated that the aquatic community was partly impaired due to the WWTF. The study reported heavy growth of algae both upstream and downstream of the facility indicating the WWTF was not the only source of the impairment (MDNR, 2005). The 2008 303(d) List reports Piper Creek (Town Branch) as being impaired by organic sediment and unknown pollutants.

The study described above was comprised of three intensive field studies in the Piper Creek (Town Branch) watershed: a 2003-2004 biological assessment study (MDNR 2004a) and sediment deposition and organic solids evaluations in March - May 2004 and 2005 - 2006 (MDNR 2004b, MDNR 2006). The purpose of the 2003 - 2004 biological assessment study was to characterize the relative importance of the city of Bolivar WWTF to biological conditions in the stream. This characterization was determined through bioassessment, habitat and water quality monitoring at four locations in the watershed and one regional control station (Dry Creek). The Dry Creek #1 station is an unimpaired, regional control station with a watershed size and land use characteristics similar to the Town Branch/ Piper Creek watershed. The purpose of the 2005-2006 study was to evaluate the impact of fine organic solids, originating at the city of Bolivar WWTF, on Town Branch and Piper Creek (MDNR 2006). These studies provide a strong basis for understanding and quantifying impairment from sources in these water bodies.

An underlying assumption in interpreting metric values based on macroinvertebrate communities is that a healthy macroinvertebrate community is a reflection of healthy stream conditions. Mean and standard deviation values for taxa richness (TR), Ephemeroptera/ Plecoptera/Trichoptera Taxa (EPTT), Biotic Index (BI), Shannon Diversity Index (SDI), percent Ephemeroptera, percent Plecoptera, percent Trichoptera and percent composition of the dominant macroinvertebrate families from the Piper Creek, Town Branch and small regional control stations are presented in Appendix A. Taxa richness, EPTT, SDI, percent Ephemeroptera and percent Trichoptera were much higher and BI was much lower at the small regional control stations than the control and test stations at Piper Creek and Town Branch. Both the control and test stations for Piper Creek and Town Branch did not have macroinvertebrate communities comparable to the small regional control stations based on community composition and stream condition index (SCI) scores. Mayflies were in higher abundance at the small regional control stations while chironomids, tubificid worms and planarians were more abundant at the Piper Creek and Town Branch stations. Caenidae, Heptageniidae, Isonychiidae, Psephenidae and Arachnoidea were the more abundant families at the small regional control stations while Elmidae, Planariidae, Chironomidae and Tubificidae were more abundant in the Piper Creek and Town Branch stations. These macroinvertebrate abundances indicate that water quality tolerant species pre-dominate the stream biology.

Spring 2004 data showed that TR, EPTT, percent Ephemeroptera, percent Plecoptera and percent Trichoptera were much higher at Dry Fork #1 than the sampling stations on Town Branch and Piper Creek (Appendix A). Taxa richness, EPTT, percent Ephemeroptera, percent

Plecoptera and percent Trichoptera were very low at the Town Branch and Piper Creek sampling stations except for percent Ephemeroptera at Piper Creek #2. No stoneflies were present at the Town Branch sampling stations. Chironomids were more abundant at Town Branch/Piper Creek sampling stations than Dry Fork #1. Chironomids were especially high in abundance at the Town Branch sampling stations. *Cricotopus/Orthocladius*, *Polypedilum convictum* group and *Dicrotendipes* made up much of the chironomid abundance at the Town Branch stations. *Cricotopus/Orthocladuis*, *Polypedilum* convictum group and *Eukiefferiella* made up for most of the chironomid abundance at Piper Creek. Elmid beetles, primarily *Stenelmis*, were abundant at all of the sampling stations. Tubificid worms were fairly abundant at the sampling stations except at Town Branch #2. Planariidae was much more abundant at the two test stations below the Bolivar WWTF discharge (Town Branch #1 and Piper Creek #1). The results of this spring study also indicate water quality tolerant species exist in the stream and dominate Town Branch/Piper Creek.

Primary conclusions of these studies are as follows:

Town Branch

- Evidence of nutrient enrichment (excess algae growth) was present both above and below the WWTF discharge suggesting that both point and nonpoint sources are contributors to biological impairment.
- Town Branch was characterized as having poor habitat; sedimentation was high, pools composed a very small percentage of the sample reach and substrate was very poor for macroinvertebrates. Downstream of the WWTF, epifaunal substrate[10], bank vegetative protection and riparian zone were characterized as poor or marginal.
- The mean sediment deposition value above and below the WWTF discharge was found, on average, to be 78 percent and 90 percent, respectively.
- Most of the effects of nutrient enrichment appeared to be due to the WWTF. In 2003, all macroinvertebrate metrics at stations downstream of the WWTF showed a decline compared to stations upstream of the WWTF.
- The importance of VSS as a contributor to impairment was assessed in both studies. The 2003 - 2004 study found other factors such as habitat, sediment deposition and nutrient enrichment to be greater contributors to impairment than VSS while the 2005 - 2006 study found evidence of significant VSS impairment. The 2005 - 2006 study concluded that "fine sediment percent cover estimations and sediment characterization analysis of this study do show evidence of significant VSS impairment of Town Branch by the Bolivar WWTP" [Wastewater Treatment Plant], and that "the notable differences during [the 2003 - 2004 and 2005 - 2006] survey periods between the two Town Branch sites indicate the Bolivar WWTP as a significant source of impairment."

Piper Creek

- The upstream control sample location showed evidence of poor to marginal habitat. Sediment deposition, bank vegetative protection and riparian zone width scored in either

[10] Epifanual substrate is material on the creek bed used by organisms that live on the material.

the poor or marginal scoring category. The influence of adjacent pasture land on erosion and sedimentation was noted.

- The macroinvertebrate community appears to recover between the downstream Town Branch monitoring location and the downstream Piper Creek monitoring location. Water quality, riparian conditions and instream habitat improved at the downstream Piper Creek monitoring location. At this location below the confluence of Town Branch and Piper Creek, sediment deposition was low (17 - 18 percent sediment coverage).

In July 2009 and August 2009, two 48-hour WLA studies were conducted on Piper Creek during summer ambient or low-flow conditions. The 48-hour studies consisted of the collection of one early morning (e.g., 05:00 - 07:30 AM) and one early afternoon (e.g., 12:00 - 2:30 PM) grab sample at each of the four sampling locations (Figure 5), over a consecutive two-day period. The first WLA study was conducted during July 15 - 16, 2009, while the second WLA study was conducted on August 19 - 20, 2009. A detailed summary of monitoring activities conducted during these periods is provided in a separate report (EPA, 2009a). Results from the monitoring are provided in Table 3 through Table 6 and are discussed in this section.

In both of the 48-hour sampling events, temperature and DO generally displayed lower values in the early morning and higher values in the afternoon. The pH readings at all locations throughout both sampling events ranged from 7.73 to 9.20. These values are consistent with those typically expected for a surface water body. Ammonia was below the laboratory detection reporting limit for all samples. Concentrations of nitrate+nitrite (NO_3+NO_2), total kjeldahl nitrogen (TKN), total nitrogen (TN) (calculated by adding the NO_3+NO_2 and the TKN concentrations), total phosphorous (TP) and $CBOD_5$ during both of the WLA events were lowest at the sample location upstream of the WWTF with the exception of TKN on July 15, NO_3+NO_2 on July 16, TKN on August 19 and TKN and NO_3+NO_2 on August 20. In most cases, the concentrations of all of these analytes were highest at the two locations immediately below the WWTF and the concentrations decreased with an increase in distance downstream. This indicates that the nutrients during these sampling events likely originated from the Bolivar WWTF.

The studies (MDNR, 2004a; MDNR, 2004b; MDNR, 2006; and EPA, 2009a) conducted on Piper Creek (Town Branch) identify several pollutants that may be leading to the impairment of aquatic life. The pollutants include:

- Nutrients (TN and TP) from nonpoint and point sources that may contribute to excessive algae growth above and below the Bolivar WWTF;
- Sediment (TSS) from nonpoint and point sources that may contribute to sedimentation and poor substrate habitat and;
- Low DO caused by decaying organic solids, as measured by $CBOD_5$, high consumption of oxygen from decaying matter on the streambed below the Bolivar WWTF and physical factors associated with low reaeration rates.

Based on this assessment, TMDLs for Piper Creek (Town Branch) will be calculated for TSS, TN, TP and CBOD.

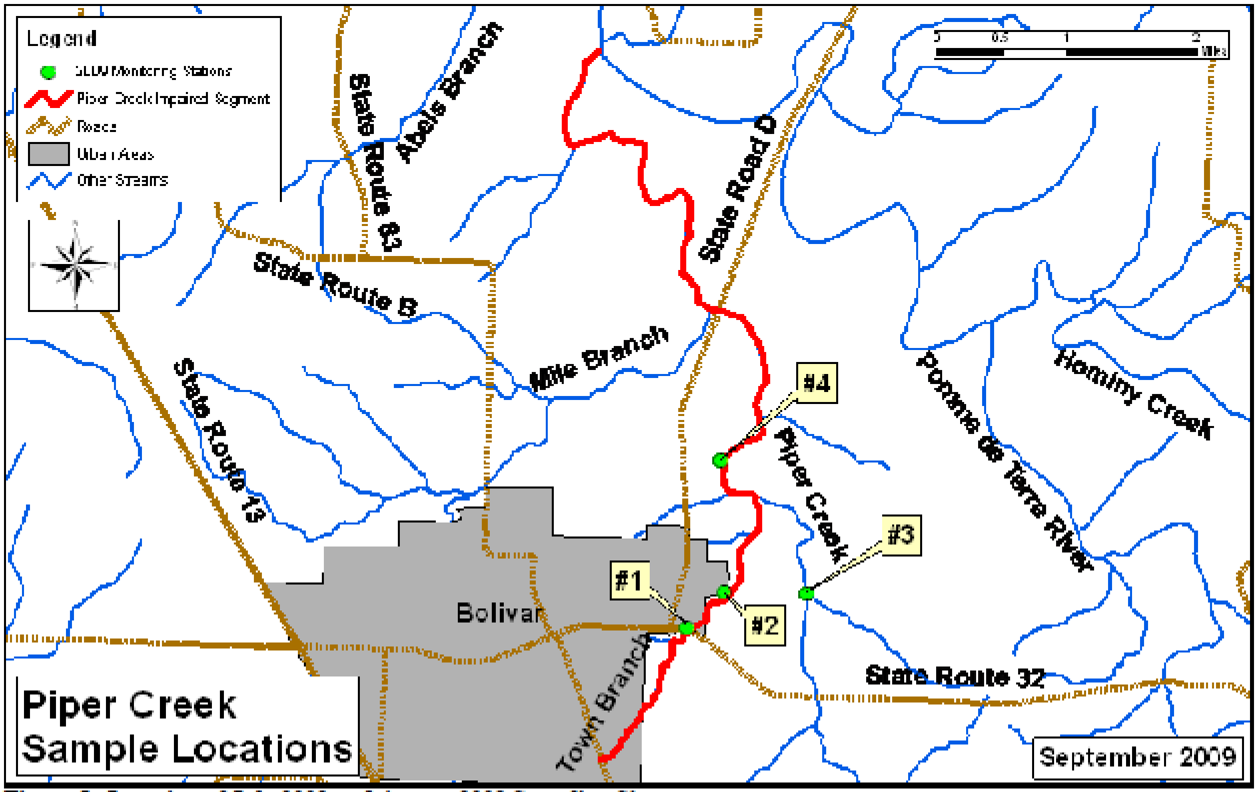

Figure 5. Location of July 2009 and August 2009 Sampling Sites

Table 3. Summary of Piper Creek Water Quality Data Collected on July 15, 2009

Sampling Location	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	NH_3 Nitrogen (mg/L)	TKN Nitrogen (mg/L)	NO_2+NO_3 Nitrogen (mg/L)	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	6:15 AM	0.275	0.496	2.500	< 0.500	0.611	1.080	7.730	7.990	22.510	0.059
1	1:00 PM	0.116	0.273	1.800	< 0.500	0.912	1.160	9.820	8.430	24.310	0.042
2	7:25 AM	0.297	0.399	2.200	< 0.500	0.602	2.080	7.370	8.230	22.890	0.840
2	1:50 PM	0.199	0.316	1.600	< 0.500	0.495	2.645	8.340	8.470	25.050	1.230
3	8:50 AM	0.057	0.006	2.100	< 0.500	1.211	0.520	7.080	8.260	23.980	0.120
3	2:50 PM	0.108	0.012	2.600	< 0.500	1.385	0.610	9.200	8.340	26.910	0.117
4	9:00 AM	0.359	0.166	2.000	< 0.500	0.787	1.610	7.900	8.500	23.540	0.530
4	3:20 PM	0.433	0.201	1.100	< 0.500	1.159	1.690	9.170	8.680	25.900	0.660

Notes: cms = cubic meters per second; m/sec = meters per second; mg/L = milligrams per liter; $CBOD_5$ = Carbonaceous Biochemical Oxygen Demand (5 days); TKN = Total Kjeldahl Nitrogen; NO_2+NO_3 = Nitrite + Nitrate; DO = Dissolved Oxygen; Temp. = Temperature in degrees Celsius; TP = Total Phosphorus

Table 4. Summary of Piper Creek Water Quality Data Collected on July 16, 2009

Sampling Location	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	NH_3 Nitrogen (mg/L)	TKN Nitrogen (mg/L)	NO_2+NO_3 Nitrogen (mg/L)	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	5:20 AM	0.050	0.156	1.000	< 0.500	0.142	1.700	7.930	8.460	21.860	0.035
1	1:00 PM	0.044	0.141	0.700	< 0.500	0.270	1.795	11.680	8.910	23.960	0.035
2	6:15 AM	0.101	0.211	0.700	< 0.500	1.026	3.480	7.590	8.490	23.200	1.365
2	2:20 PM	0.103	0.214	1.100	< 0.500	0.709	4.170	8.600	8.660	25.600	1.910
3	7:50 AM	0.021	0.002	1.400	< 0.500	0.622	0.580	5.450	8.420	24.360	0.077
3	3:20 PM	0.016	0.002	1.400	< 0.500	1.355	0.550	6.550	8.410	25.110	0.071
4	8:20 AM	0.306	0.162	1.300	< 0.500	0.735	2.040	8.490	8.780	24.340	0.770
4	3:30 PM	0.204	0.115	1.200	< 0.500	0.758	2.160	9.550	9.200	26.840	0.750

Notes: cms = cubic meters per second; m/sec = meters per second; mg/L = milligrams per liter; $CBOD_5$ = Carbonaceous Biochemical Oxygen Demand (5 days); TKN = Total Kjeldahl Nitrogen; NO_2+NO_3 = Nitrite + Nitrate; DO = Dissolved Oxygen; Temp. = Temperature in degrees Celsius; TP = Total Phosphorus

Table 5. Summary of Piper Creek Water Quality Data Collected on August 19, 2009

Sampling Location	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	NH_3 Nitrogen (mg/L)	TKN Nitrogen (mg/L)	NO_2+NO_3 Nitrogen (mg/L)	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	5:20 AM	0.033	0.120	1.100	< 0.500	2.944	1.650	6.810	8.030	18.710	0.024
1	1:00 PM	0.046	0.146	2.100	< 0.500	1.384	1.900	10.390	8.400	21.690	0.024
2	6:15 AM	0.075	0.166	1.600	< 0.500	7.000	6.000	6.190	7.920	19.960	0.630
2	1:30 PM	0.122	0.217	2.400	< 0.500	1.319	6.700	8.740	8.340	22.780	0.694
3	6:50 AM	0.029	0.004	1.900	< 0.500	0.496	0.325	2.670	7.710	20.450	0.090
3	2:05 PM	---	---	1.600	< 0.500	0.366	0.260	3.680	7.750	21.400	0.039
4	8:15 AM	0.166	0.099	0.850	< 0.500	0.668	3.550	6.400	8.130	20.140	0.360
4	3:05 PM	0.185	0.103	2.100	< 0.500	1.237	3.500	10.130	8.750	23.120	0.340

Notes: cms = cubic meters per second; m/sec = meters per second; mg/L = milligrams per liter; $CBOD_5$ = Carbonaceous Biochemical Oxygen Demand (5 days); TKN = Total Kjeldahl Nitrogen; NO_2+NO_3 = Nitrite + Nitrate; DO = Dissolved Oxygen; Temp. = Temperature in degrees Celsius; TP = Total Phosphorus. Values denoted --- were too small to measure or compute.

Table 6. Summary of Piper Creek Water Quality Data Collected on August 20, 2009

Sampling Location	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	NH_3 Nitrogen (mg/L)	TKN Nitrogen (mg/L)	NO_2+NO_3 Nitrogen (mg/L)	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	5:15 AM	0.029	0.105	1.500	< 0.500	0.985	1.960	6.840	8.020	19.360	0.021
1	1:00 PM	0.027	0.097	1.300	< 0.500	0.827	1.780	10.950	8.340	21.980	0.019
2	5:50 AM	0.072	0.163	1.100	< 0.500	0.847	6.300	5.700	7.950	20.650	0.550
2	1:45 PM	0.091	0.189	1.700	< 0.500	0.646	8.400	7.840	8.210	23.000	0.670
3	7:05 AM	0.103	0.012	1.300	< 0.500	0.768	0.257	2.770	7.730	21.030	0.033
3	2:20 PM	0.001	0.000	1.500	< 0.500	2.973	0.255	4.900	7.710	22.160	0.029
4	8:15 AM	0.165	0.105	1.200	< 0.500	1.067	4.000	6.560	8.090	20.740	0.400
4	3:05 PM	0.199	0.105	1.400	< 0.500	0.614	3.600	10.110	8.770	23.520	0.330

Notes: cms = cubic meters per second; m/sec = meters per second; mg/L = milligrams per liter; $CBOD_5$ = Carbonaceous Biochemical Oxygen Demand (5 days); TKN = Total Kjeldahl Nitrogen; NO_2+NO_3 = Nitrite + Nitrate; DO = Dissolved Oxygen; Temp. = Temperature in degrees Celsius; TP = Total Phosphorus

As discussed in Sections 4 and 5, the low DO problem could be due to one or more of the following:

- Excessive loads of decaying organic solids, as measured by BOD.
- Too much algae in the stream as a result of excessive phosphorus or nitrogen loading.
- High consumption of oxygen from decaying matter on the streambed.
- Higher temperatures due to loss of riparian vegetative canopy.

4 SOURCE INVENTORY

A source assessment is used to identify and characterize the known and suspected sources contributing to impairment in Piper Creek. For the purpose of this report, sources have been divided into two broad categories: point sources and nonpoint sources. Point sources can be defined as sources, either constant or time transient which occur at a fixed location in a watershed. Nonpoint sources are generally accepted to be diffuse sources not entering a water body at a specific location. Nutrients and oxygen consuming substances from both point and nonpoint sources are considered to be the primary contributors to impairment in Piper Creek. Historic water quality data used to identify and assess sources is presented in Appendix A of this document.

4.1 Point Sources

The term "point source" refers to any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit, by which pollutants are transported to a water body. For the purposes of TMDL development, point sources are defined as sources regulated through the National Pollutant Discharge Elimination System (NPDES) program. Missouri has its own program for administering the NPDES program, referred to as the Missouri State Operating Permit System (MSOPS). The NPDES and MSOPS programs are the same and for the purposes of this document the term "NPDES" will be used. The following NPDES-regulated entities are included in this source category:

- Municipal and industrial WWTF,
- Concentrated animal feeding operations (CAFOs),
- Storm water runoff from Municipal Separate Storm Sewer Systems (MS4s) and
- General permitted facilities (including storm water runoff from construction and industrial sites).

General permits (as opposed to site specific permits) are issued to activities that are similar enough to be covered by a single set of requirements. Storm water permits are issued to activities that discharge only in response to precipitation events. Point sources in Piper Creek were identified by consulting EPA's Permit Compliance System (PCS) website[11] and Missouri's GIS inventory[12] of storm water and general NPDES-permitted facilities.

Point sources in Piper Creek watershed are listed in Table 7 and shown in Figure 6. Of those listed, five are site specific permits, three are general permits and the remaining twelve are storm water permits. Five permittees are required to monitor and report effluent or storm water concentrations.

[11] www.epa.gov/enviro/html/pcs/index.html
[12] http://msdis.missouri.edu/datasearch/ThemeList.jsp; GIS layers updated May 2009 and June 2009

Table 7. Permitted Facilities in the Piper Creek Watershed

Facility ID	Facility Name	Receiving Stream	Classification/ Description	Discharge Sampling Requirements[1]	Design Flow (MGD)[2]	Permit Expiration Date
MO0022373	City of Bolivar WWTF	Town Branch	Sewerage system	Unionized NH_3, Total NH_3, DO, TP, TN, TSS, Temperature, BOD_5, pH, Flow, O&G, FC, WET	2.55	2013
MO0097594	Home Court Advantage, Inc. WWTF	Unnamed Tributary to Mile Branch which flows to Piper Creek	Group Home/ Sewerage Works	Flow, BOD_5, TSS, pH, Fecal Coliform, NH_3, Temperature and DO (quarterly monitoring)	0.007	2009
MO0116467	Quail Creek Mobile Home Park WWTF	Unnamed Tributary to Piper Creek	Mobile Home Park/ Sewerage Works	Flow, BOD_5, TSS, pH, TP (quarterly monitoring)	0.01395	2010
MO0121754	Silo Ridge Homeowners Association WWTF	Unnamed Tributary to Piper Creek	Subdivision / Sewerage Works	Flow, BOD_5, TSS, pH, Fecal Coliform, TRC, NH_3, Temperature, DO (quarterly monitoring)	0.016830	2008
MO0121924	Karlin Place Subdivision WWTF	Unnamed Tributary to Piper Creek	Commercial Park/ Subdivision/ Sewerage Works	Flow, BOD_5, TSS, pH, Fecal Coliform, NH_3, Temperature and DO (quarterly monitoring)	0.021	2013
MOG350232	Carl White Oil Company	Town Branch Tributary	Bulk terminal petroleum station	pH, O&G, TROP, Ethanol, Ethyl Benzene, flow	General Permit	2012
MOG490247	Ewing Concrete Materials	Mile Branch Tributary	Crushed and broken limestone	pH, O&G, TSS, Flow, Settleable Solids	General Permit	2011
MOG490263	Bolivar Ready Mix & Material	Town Branch Tributary	Crushed and broken limestone	pH, O&G, TSS, Flow, Settleable Solids	General Permit	2011
MOR109R13	Industrial Development	Piper Creek Tributary	Heavy Construction	NA	Storm water permit	2012

Table 7. Permitted Facilities in the Piper Creek Watershed (continued)

Facility ID	Facility Name	Receiving Stream	Classification/ Description	Discharge Sampling Requirements	Design Flow (MGD)	Permit Expiration Date
MOR109S12	Burlington Heights Subdivision	Town Branch Tributary	Heavy Construction	NA	Storm water permit	2012
MOR109S57	Monarch Landing	Town Branch	Heavy Construction	NA	Storm water permit	2012
MOR10A541	Settler's Village	Town Branch	Heavy Construction	NA	Storm water permit	2012
MOR10B098	Walgreen	Town Branch	Heavy Construction	NA	Storm water permit	2012
MOR10B515	Stonebridge Estates	Town Branch	Heavy Construction	NA	Storm water permit	2012
MOR10C027	ALDI	Town Branch	Heavy Construction	NA	Storm water permit	2012
MOR10C083	Highline Village	Town Branch Tributary	Heavy Construction	NA	Storm water permit	2012
MOR203016	Tracker Marine	Town Branch	Boat building and repairing	NA	Storm water permit	2009
MOR240033	Bolivar Farmers Exchange Fertilizer	Town Branch Tributary	Farm supplies	NA	Storm water permit	2014
MOR240221	Hawk Fertilizer	Town Branch Tributary	Farm supplies	NA	Storm water permit	2014
MOR60A120	Yeargain Steel & Salvage Yard	Mile Branch Tributary	Motor vehicle parts, used	NA	Storm water permit	2013

[1] Where DO = Dissolved Oxygen, NH_3 = Ammonia, BOD = Biochemical Oxygen Demand, TSS = Total Suspended Solids, TN = Total Nitrogen, TP = Total Phosphorus O&G = Oil and Grease, WET = Whole Effluent Toxicity, FC = Fecal Coliform, TRC = Total Residual Chlorine, TROP = Total Recoverable Oil Petroleum; "NA" = Not Applicable. Permits identified as "NA" are storm water or general permits.
[2] MGD = Million Gallons per Day. 1MGD = 1.547229 cubic feet per second (cfs). 1 cfs = 0.6463169 MGD.

The city of Bolivar WWTF (MO0022373) is located in Bolivar, Missouri. The current NPDES permit became effective in April 2008 and expires in April 2013. The facility was designed to accommodate a population of 25,365 people with a design flow of 2.55 million gallons per day (MGD) and sludge production of 533 dry tons sludge/year. According to the 2008 permit, actual flows average 1.4 MGD. The facility maintains one outfall to Town Branch. Two monitoring locations are specified in the permit. Monitoring location S1 is located on Town Branch at the State Highway 32 Bridge, approximately 340 meters upstream of outfall 001 and monitoring location S2 is located at the Division Street Bridge, approximately 360 yards downstream of outfall 001.

Home Court Advantage, Inc. WWTF (also identified as Hillside Estates on the EPA PCS website) (MO0097594) is located in Bolivar, Missouri, and became effective September 2004 and expired September 2009. The facility was designed to accommodate a population of 70 people with a design flow of 7,000 gallons per day and sludge production of 1.5 dry tons sludge/year. The facility maintains one outfall at Mile Branch, a tributary to Piper Creek.

The Quail Creek Mobile Home Park WWTF (MO0116467) is located on Route 4 in Bolivar, Missouri. This facility maintains one discharge to an unnamed tributary of Piper Creek upstream of the confluence of Town Branch with Piper Creek. The facility was designed to accommodate a population of 186 with a design flow of 13,950 gallons per day (adjusted design flow is 6,999 gallons per day) and sludge production of 3 dry tons/year.

The Silo Ridge Homeowners Association WWTF (MO0121754) is in Bolivar, Missouri. This facility maintains a single discharge to an unnamed tributary of Piper Creek upstream of the confluence of Town Branch with Piper Creek. The facility was designed to accommodate a population of 237 with a design flow of 16,830 gallons per day (adjusted design flow is 4,999 gallons per day) and a design sludge production of 1.66 dry tons/year.

Karlin Place Subdivision WWTF (MO0121924) is located in Bolivar, Missouri. This facility maintains a single discharge to an unnamed tributary of Piper Creek upstream of the confluence of Town Branch with Piper Creek. The facility was designed to accommodate a population of 190 with a design flow of 21,000 gallons per day and a design sludge production of 1.33 dry tons/year.

Of these WWTFs, the city of Bolivar WWTF (MO0022373) is the only point source that discharges directly to the 303(d)-listed portions of Town Branch/Piper Creek.

There are eight storm water permits that are classified as heavy construction, which is designated as land disturbance, including construction or land disturbance greater than one acre. This type of permit authorizes wastewater and storm water discharges with requirements that discharges do not cause an exceedance of the state WQSs (10 CSR 20-7.031) and that the permittee develop and implement a Storm Water Pollution Prevention Plan (SWPPP). Since the permit is for storm water discharges, it will likely have minimal impact on DO concentrations in the stream as the measured DO exceedances occurred during low flow conditions. However, it is possible that these permits may have an impact on organic sediment and sediment oxygen demand (SOD).

Storm water permit MOR203016 (Tracker Marine) is classified as boat building and repairing, which authorizes the discharge of storm water runoff from facilities having Standard Industrial Classification (SIC) codes including 2514, 2522, 2542, 33xx, 34xx, 35xx, 36xx, 37xx and 38xx. In general these codes represent metal, electrical and industrial equipment used for storage and transportation.

Storm water permits MOR240033 (Bolivar Farmers Exchange Fertilizer) and MOR240221 (Hawk Fertilizer) are classified as farm supplies which authorizes the discharge of containment water to waters of the state of Missouri from an agrichemical facility.

Storm water permit MOR60A120 (Yeargain Steel and Salvage Yard) is classified as used motor vehicle parts, which authorizes the discharge of storm water runoff to waters of the state of Missouri from motor vehicle salvage yards and auto/truck recycling operations.

General permits MOG490247 (Ewing Concrete Materials) and MOG490263 (Bolivar Ready Mix and Material) are classified as crushed and broken limestone which authorizes wastewater discharges from limestone and other rock quarries, concrete, glass and asphalt industries.

General permit MOG350232 (Carl White Oil Company) is classified as a bulk terminal petroleum station which authorizes storm water discharges from facilities with above-ground storage capacity totaling more than 20,000 gallons but less than 250,000 gallons of ethanol or biodiesel.

Storm water and general permits shown in Table 7 and discussed in this section will not have a significant impact on Piper Creek water quality during low flow events; however, these sources may contribute nutrients and sediment during runoff events that may impact water quality in the stream.

Illicit straight pipe discharges of household wastes (i.e., a pipe that transports human waste from a household directly to a stream or lake) are also potential point sources in rural areas. These sources are discharged directly into streams or land areas and are different than illicitly connected sewers. There is no specific information on the number of illicit straight pipe discharges of household wastes in the Piper Creek watershed. Leaking or illicitly connected sewers can also be a significant source of pollutant loads within urban areas.

4.1.1 Runoff from MS4 Urban Areas

There are no Phase I or Phase II regulated communities within the Piper Creek watershed at this time.

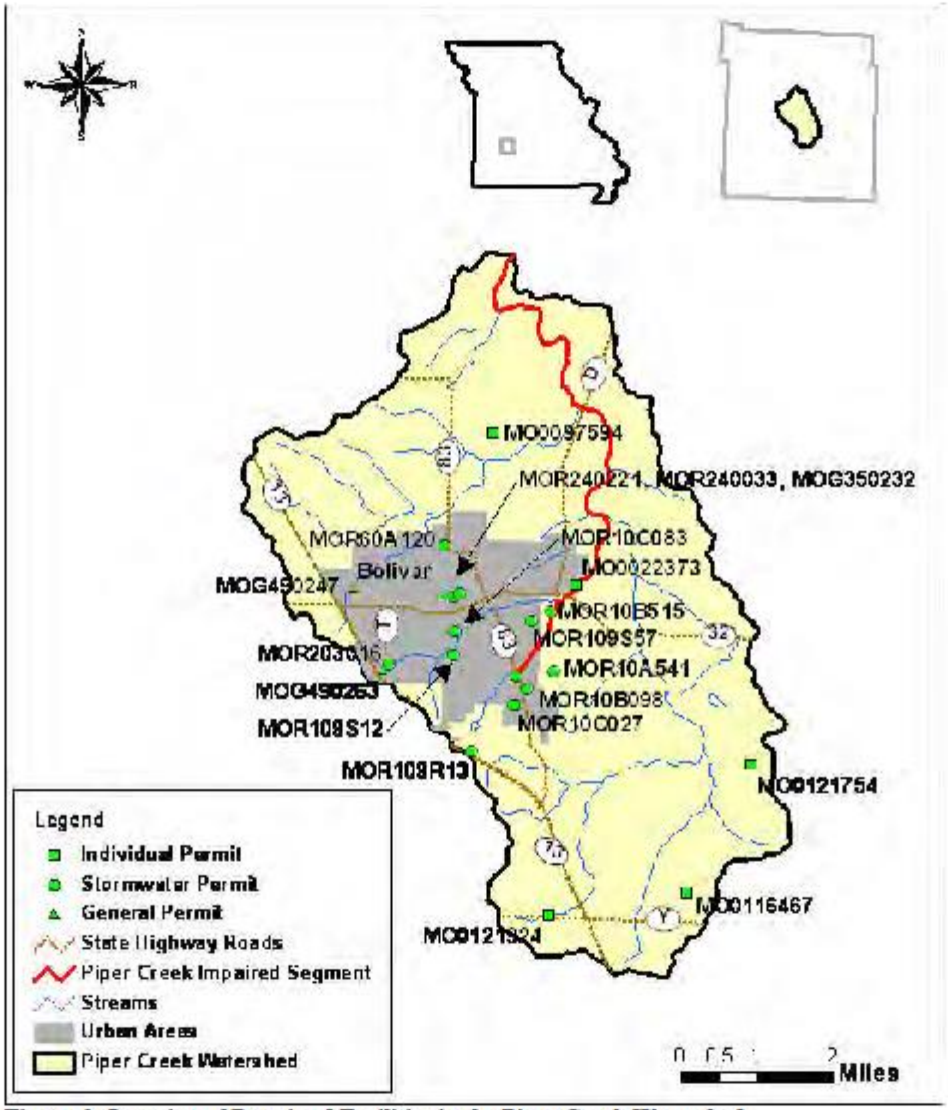

Figure 6. Location of Permitted Facilities in the Piper Creek Watershed

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4.2 Nonpoint Sources

Nonpoint sources include all other categories of pollutant sources not classified as point sources. Potential nonpoint sources contributing to low DO problems in the Piper Creek watershed include runoff from agricultural areas, runoff from urban areas, onsite wastewater treatment systems and various sources associated with riparian habitat conditions. Additional discussion on nonpoint sources is provided in the following sections.

Based on the information before us, the decision to apply discharges associated with unpermitted sources to the LA, as opposed to the WLA for purposes of this TMDL, is acceptable. The decision to allocate these sources to the LA does not reflect any determination by EPA as to whether these discharges are, in fact, unpermitted point source discharges within this watershed. In addition, by approving these TMDLs with some sources treated as LAs, EPA is not determining that these discharges are exempt from NPDES permitting requirements. If sources of the allocated pollutant in this TMDL are found to be, or become, NPDES-regulated discharges, their loads must be considered as part of the calculated sum of the WLA in this TMDL. WLA in addition to that allocated here is not available.

4.2.1 Runoff from Agricultural Areas

Lands used for agricultural purposes can be a source of nutrients and oxygen consuming substances. Accumulation of nitrogen and phosphorus on cropland occurs from decomposition of residual crop material, fertilization with chemical and manure fertilizers, atmospheric deposition, wildlife excreta and irrigation water. The 2005 land use/land cover data indicates there are 1.5 square miles of cropland in the watershed, which comprises 4 percent of the entire watershed (Table 2). An assessment of cropland in the riparian buffer of the impaired stream segment showed cropland to be approximately 1 percent (Table 8).

U.S. Geological Survey (USGS) HUC 8 data taken from the United States Department of Agriculture (USDA) Census of Agriculture (USDA, 2002) were combined with the land cover data for the Piper Creek watershed to estimate approximately 3,122 cattle in the watershed[13]. The cattle are most likely located on the approximately 23.3 square miles of grassland in the watershed; and runoff from these areas can be potential sources of nutrients and oxygen consuming substances. Animals grazing in pasture areas deposit manure directly upon the land surface and even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event. In addition, when pasture land is not fenced off from the stream, cattle or other livestock may contribute nutrients to the stream while walking in or adjacent to the water body. The low density of cattle in the Piper Creek watershed (84 cattle per square mile) suggests they are unlikely to be a significant source of pollutants. The USDA Census of Agriculture also reports there were 4,915 hogs, 510 sheep, 2,799 horses, 11,798 chickens,

[13] According to the USDA Census of Agriculture there are approximately 56,196 head of cattle and 420.3 square miles of pasture/rangeland in the Pomme De Terre Watershed (HUC 10290107) (USDA, 2002). These two values result in a cattle density of approximately 134 cattle per square mile of grasslands. This density was multiplied by the number of grassland square miles in the Piper Creek watershed to estimate the number of cattle in the watershed.

232,540 turkeys and 43 ducks in the Pomme De Terre Watershed (HUC 10290107) (USDA, 2002). No data are available to estimate the number of these other livestock that might be located in the Piper Creek watershed. Since none of the agricultural operations are CAFOs and the density of cattle is low, it is unlikely that runoff from agricultural areas is a significant source of TSS, TN or TP loads to the watershed.

Permitted CAFOs identified in this TMDL are part of the assigned WLA. At this time, animal feeding operations (AFOs) and unpermitted CAFOs are considered under the LA because we do not currently have enough detailed information to know whether these facilities are required to obtain NPDES permits. This TMDL does not reflect a determination by EPA that such facility does not meet the definition of a CAFO nor that the facility does not need to obtain a permit. To the contrary, a CAFO that discharges or proposes to discharge has a duty to obtain a permit. If it is determined that any such operation is an AFO or CAFO that discharges, any future WLA assigned to the facility must not result in an exceedance of the sum of the WLAs in this TMDL as approved.

Any CAFO that does not obtain a NPDES permit must operate as a no discharge operation. Any discharge from an unpermitted CAFO is a violation of Section 301. It is EPA's position that all CAFOs should obtain a NPDES permit because it provides clarity of compliance requirements, authorization to discharge when the discharges are the result of large precipitation events (e.g., in excess of 25-year and 24-hour frequency/duration) or are from a man-made conveyance.

4.2.2 Runoff from Non-MS4 Urban Areas

Storm water runoff from impervious surfaces, high intensity urban areas and low intensity urban areas can also be a source of pollutants. Nutrients, organic matter and sediments from urban storm water runoff can contribute to degraded water quality and impact aquatic life. Excessive nutrients from fertilizers, pet waste and urban wildlife can contribute to nuisance algae and rooted aquatic plants, which may contribute to low DO concentrations. Phosphorus loads from residential areas can be comparable to or higher than loading rates from agricultural areas (Reckhow et al., 1980; Athayde et al., 1983). Organic matter in storm water runoff may originate from failing septic tanks, leaking sewers, yard waste, animal waste and natural organic material. Decomposition of this material consumes oxygen and may reduce DO concentrations in aquatic environments. Storm water runoff from urban areas such as parking lots and buildings is also warmer than runoff from grassy and woodland areas, which can lead to higher temperatures that lower the DO saturation capacity of the stream. Excessive discharge of suspended solids from urban areas may lead to streambed siltation problems and contribute to SOD within streams.

Since approximately 14.2 percent of the Piper Creek watershed is classified as urban and much of this area drains directly to the impaired reach, it is likely that urban storm water runoff contributes to the impairment. This source will be considered in developing the TMDL.

4.2.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (e.g., septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. When these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface waters. Failing septic systems release nutrients and pathogens that can reach nearby streams through both runoff and groundwater flows.

The exact number of onsite wastewater treatment systems in the Piper Creek watershed is unknown. However, as discussed in Section 2.4, the estimated rural population in the Piper Creek watershed is approximately 747 persons. Based on this population and on an average density of 2.4 persons per household, there may be approximately 311 systems in the watershed or approximately one septic system for every 64 acres of rural area. Based on aerial imagery, most of the septic systems are thought to be evenly disbursed throughout the rural portion of the watershed located outside the limits of the city of Bolivar. These areas are predominately used for agriculture. No site specific studies have indicated that localized failure of onsite wastewater treatment systems are a problem in the Piper Creek (Town Branch) watershed. EPA reports that the statewide failure rate of onsite wastewater systems in Missouri is between 30 and 50 percent (EPA, 2002). Failing onsite wastewater treatment systems could be a significant source of pollutants if the failure rate is close to the EPA estimate. However, given that the number of septic systems is relatively small (one system per 64 acres of rural land) and that field studies have not identified the presence of failing septic systems in this watershed, this source is not considered a significant source of pollutants at this time.

4.2.4 Riparian Habitat Conditions

Riparian[14] (streamside) habitat conditions can have a strong influence on instream DO, TSS, TN and TP. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal and assimilation of nutrients from or by the water column. Therefore, a stream with good riparian habitat is able to moderate higher TSS and nutrient loads than a stream with poor riparian habitat. Riparian buffers can stabilize stream banks and reduce soil erosion. Riparian buffers stabilize the stream banks by providing a root network that helps hold soil in place, reducing instream TSS. In addition, riparian buffers can reduce stream temperatures by providing more shading and thus increase DO carrying capacity in the stream. However, riparian buffers can be the source of undesirable natural material generated in the stream, which may cause low DO problems. For example, leaf fall from vegetation near the water's edge, aquatic plants and drainage from organically rich areas like swamps and bogs are all natural sources of material that consume oxygen.

As indicated in Table 8, approximately half of the land in the Piper Creek 30-meter riparian corridor is classified as forest (MoRAP, 2005). Grassland, including pasture areas, covers approximately one-third of the riparian corridor. Compared to wooded areas, grasslands have the potential to provide much less shading and higher nutrient loads due to livestock activity.

[14] A riparian corridor (or zone or area) is the linear strip of land running adjacent to a stream bank.

Table 8. Percentage Land Use/Land Cover Within a 30-Meter Riparian Buffer

Land Use/Land Cover	Percent of Piper Creek Riparian Area (%)[1]
Barren or Sparsely Vegetated	0.0
Cropland	1.1
Forest	48.1
Herbaceous[2]	9.4
Grassland	33.4
Wetland	0.0
High Intensity Urban	0.4
Impervious	0.6
Low Intensity Urban	4.4
Open Water	2.6

[1] Source: MoRAP (2005)
[2] Herbaceous land use includes open woodland and woody shrubland (including young woodland) with less than 60% vegetated cover (MoRAP 2005)

5 APPLICABLE WATER QUALITY STANDARDS AND NUMERIC WATER QUALITY TARGETS

Section 303(d) of the CWA and Chapter 40 of the CFR Part 130 require states to develop TMDLs for waters not meeting WQS. The TMDL process quantitatively assesses the impairment factors so that states can establish water-quality based controls to reduce pollutants of concern from both point and nonpoint sources and to restore and protect the quality of their water resources.

Under the CWA, every state must adopt WQS to protect, maintain and improve the quality of the nation's surface waters (US Code Title 33, Chapter 26, Subchapter III [US Code, 2009]). These standards represent a level of water quality that will support the CWA's goal of "fishable/swimmable" waters. Missouri's Surface WQS (10 Code of State Regulation [CSR, 2009] 20-7.031) consist of three components: designated uses, criteria (general and numeric) and an antidegradation policy.

Beneficial or designated uses for Missouri streams are found in the WQS at 10 CSR 20-7.031(1)(C), (1)(F) and Table H (CSR, 2009). Criteria for designated uses are found at 10 CSR 20-7.031, Tables A and B (CSR, 2009)). Missouri's antidegradation policy is outlined at 10 CSR 20-7.031(2) (CSR, 2009).

5.1 Designated Beneficial Uses

The designated beneficial uses of Piper Creek (Class P) are:

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life

- Protection of Human Health (Fish Consumption)
- Whole Body Contact Recreation-Category B (CSR, 2009)

The impaired use is the "Protection of Warm Water Aquatic Life." The designated beneficial uses and stream classifications for Missouri may be found in the WQS at 10 CSR 20-7.031(1)(C), (1)(F) and Table H available from the Missouri Secretary of State (CSR, 2009).

5.2 Criteria

Missouri's water quality criteria that relate to DO, organic sediment and nutrients are presented in the following sections. The sections also provide brief descriptions of why these parameters are important to water quality, how they are measured and how they are related to other water quality parameters.

5.2.1 Dissolved Oxygen

The amount of DO in water is one of the most commonly used indicators of river and stream health. Under extended hypoxic (low DO) or anoxic (no DO) conditions, many higher forms of life are driven off or die. Fish, mussels, macroinvertebrates and all other aquatic life utilize DO to create energy and metabolize food. The WQS for all Missouri streams except cold water fisheries require a daily minimum of 5 milligrams per liter (mg/L) DO (10 CSR 20-7.031 Table A (CSR, 2009)).

DO in streams is affected by several factors including water temperature, the amount of decaying matter (i.e., organic sediment) in the stream, turbulence at the air-water interface and the amount of photosynthesis occurring in plants within the stream. Excessive nitrogen and phosphorus loading to water bodies can also contribute to DO problems because they can accelerate algal growth.

Algae growth in streams is most frequently assessed based on the amount of chlorophyll-a in the water. Algal growth is affected by numerous biotic and abiotic factors including light availability, flow and water velocity, nutrients (particularly nitrogen and phosphorus), grazing and other influences. Algae contribute DO during photosynthesis and consume DO during respiration. This typically results in a net gain of DO during the day and net loss of DO during the night. The breakdown of dead, decaying algae also removes oxygen from water. The most common approach to reducing excessive algal growth involves controls on activities that contribute phosphorus to the water body.

5.2.2 Organic Sediment

As previously mentioned, organic sediments can contribute to fluctuating DO concentrations. Decaying matter can come from wastewater effluent, as well as agricultural and urban runoff and is typically measured in-stream as BOD. Decaying matter can also accumulate on the bottom of a stream and cause sediment oxygen demand (SOD). SOD is a combination of all of the oxygen-consuming processes that occur at or just below the sediment/water interface. SOD is partly due to biological processes and partly due to chemical processes. Most of the

SOD at the surface of the sediment is due to the biological decomposition of organic material and the bacterially facilitated nitrification of NH_3, while SOD found several centimeters into the sediment is often dominated by the chemical oxidation of species such as iron, manganese and sulfide (Wang, 1980; Walker and Snodgrass, 1986).

High levels of organic sediment can contribute to sludge production along stream beds which smother aquatic invertebrates and fish eggs and cause offensive odors and unsightliness. Missouri's WQS do not include specific numeric criteria for this pollutant, but given the natural effects of excessive organic sediment on aquatic life, Missouri's narrative criteria are applicable [10 CSR 20-7.031(3)(A), (C), (D) and (G)] (CSR, 2009). Included in the narrative criteria are the following requirements:

- Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits, or prevent full maintenance of beneficial uses.
- Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor, or prevent full maintenance of beneficial uses.
- Waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal or aquatic life.
- Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.

There are many quantitative indicators of sediment, such as TSS, turbidity and bedload sediment, which are appropriate to describe sediment in rivers and streams (EPA, 2006). A concentration of TSS was selected to represent the numeric target for this TMDL because it enables the use of the highest quality available data and is included in monitoring data. A detailed discussion of the method used to develop the TSS target is provided in Appendix C.

5.2.3 Total Nitrogen and Total Phosphorus

An overabundance of nutrients, in particular nitrogen and phosphorus, is a serious threat to aquatic ecosystems. Excess nutrients support rapid algal growth, also referred to as algal blooms, which will cause significant changes to the water body. This phenomenon is called eutrophication. Eutrophication is the natural aging of lakes or streams caused by nutrient enrichment. Cultural eutrophication is the accelerated aging of the natural condition caused by human activities. Nutrient related water quality issues include the following:

- Proliferation of nuisance algae and the resulting unsightly and harmful bottom deposits;
- Turbidity due to suspended algae and the resulting green color;
- Organic enrichment when algal blooms die off, which perpetuates the cycle of excessive plant growth;
- Low DO caused by extreme swings in oxygen production by over abundant plant life and oxygen depletion resulting from decomposition of algae and other plants, which can have a negative impact on aquatic organisms.

Missouri does not have a numeric criterion for TN and TP in freshwater streams; therefore, targets and LCs are based on EPA-recommended Ecoregion 39 criteria and water quality observations at locations throughout the ecoregion (EPA, 2000). Reference conditions for TN and TP in level III Ecoregion 39 streams are as follows: TN = 0.289 mg/L and TP = 0.007 mg/L. For this TMDL, recommended TN and TP ecoregion criteria are used directly in developing LCs for TN and TP. A detailed discussion of the method used to develop the TN and TP targets is provided in Appendix D of this report.

5.3 Antidegradation Policy

Missouri's WQS include EPA's "three-tiered" approach to antidegradation, which may be found at 10 CSR 20-7.031(2) (CSR, 2009).

Tier 1 – Protects existing in stream uses and a level of water quality necessary to maintain and protect those uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing in stream water uses are those uses that were attained on or after November 28, 1975, the date of EPA's first WQS Regulation.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an anti-degradation review consisting of: 1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; 2) full satisfaction of all intergovernmental coordination and public participation provisions; and 3) assurance that the highest statutory and regulatory requirements for point sources and best management practices (BMPs) for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing or beneficial uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges and exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

6 MODELING APPROACH

Dissolved Oxygen (DO) in streams is determined by the factors of photosynthetic productivity, respiration (autotrophic and heterotrophic), reaeration and temperature. These factors are influenced by natural and anthropogenic conditions within a watershed. Generally, reaeration is based on the physical properties of the stream and on the capacity of water to hold DO. This capacity is mainly determined by water temperature with colder water having a higher saturation concentration for DO. In a review of variables and their importance in DO modeling, Nijboer and Verdonschot (2004) categorized the impact of a number of variables on oxygen depletion. For this TMDL, the effects of temperature and the physical aspects of the stream itself were discounted. Even though the hydrological regime of historic alluvial streams was modified by changes in land cover and channelization, manipulation of these parameters does not address a pollutant and so is not the goal of a TMDL. Pollutants which result in oxygen concentrations below saturation are:

- fine particle size of bottom sediment
- high nutrient levels (nitrogen and phosphorus)
- turbidity

An essential component of developing a TMDL is establishing a relationship between the source loadings and the resulting water quality. For this TMDL, two modeling approaches are used. The load duration curve (LDC) method is used to develop TMDLs for TSS, TN and TP under all flow conditions and the QUAL2K model is used to assess DO under low flow conditions. The relationship between the source loadings of CBOD, nutrients (NH_3, TN and TP) and algal dynamics on DO is generated by the water quality model QUAL2K (Chapra et al., 2008) under steady low flow conditions.

Since fine particle sized sediment and turbidity are derived from similar loading conditions of terrestrial and stream bank erosion, this TMDL establishes an allocation for TSS (see Appendix C for discussion of development of TSS targets). This target was derived based on a reference approach by targeting the 25th percentile of TSS measurements (USGS, non-filterable residue) in the Ozark/Osage geographic region in which Piper Creek is located. To address nutrient levels, the EPA nutrient ecoregion reference concentrations were used. For the Level III 39 Ecoregion where Piper Creek is located, the reference concentration for TN is 0.289 mg/L and the reference concentration for TP is 0.007 mg/L (EPA, 2000). This TMDL will not specifically target chlorophyll as a WLA, but will use a linkage between nutrient concentrations and chlorophyll response to achieve the ecoregion reference concentrations.

6.1 Load Duration Curves

The sediment target for this TMDL was derived using a reference approach by targeting the 25th percentile of TSS measurements (USGS, non-filterable residue) in the geographical region in which Piper Creek is located (see Appendix C for a list of sites and data). In this approach, the target for pollutant loading is the 25th percentile of the current EDU condition calculated from all data available within the EDU in which the water body is located. Therefore, the 25th percentile is targeted as the TMDL LDC.

To develop LDCs for TN and TP, a method similar to that used for TSS was employed. First, TN and TP measurements were collected from USGS sites in the vicinity of the impaired stream. These data were adjusted such that the median of the measured data was equal to the ecoregion reference concentration. This was accomplished by subtracting the difference of the data median and the reference concentration. Where this would result in a negative concentration, the data point in question was replaced with the minimum concentration seen in the measured data. This resulted in a modeled data set which retained much of the original variability seen in the measured data. This modeled data was then regressed as instantaneous load versus flow. The resultant regression equation was used to develop the LDC. Allowable pollutant loads were calculated for all flow conditions by multiplying flow by either the EPA-recommended ecoregion reference concentration or the concentration established using the regional streams, whichever concentration is higher.

To develop the TMDL expression of maximum daily loads, the background discharge at the stream outlet was modified from the traditional approach using synthetic flow estimation. Since the design flow from permitted facilities would overwhelm the background natural low flow, the sum of permitted volumes was added to the derived stream discharge at all percentiles of flow to take into account the increases in flow volume as well as pollutant load. The TMDL curves in the LDCs flatten at low flow because at these lower flows the TMDL target is dominated by the point source flow.

6.2 QUAL2K

QUAL2K and its predecessor models have been used extensively for permitting of wastewater treatment discharges and TMDL development across the country. QUAL2K is supported by EPA and is well accepted within the scientific community because of its proven ability to simulate the processes important to DO conditions within streams. QUAL2K is suitable for simulating the hydraulics and water quality conditions of a small river. It is a one-dimensional model with the assumption of a completely mixed system for each computational cell. QUAL2K assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the longitudinal direction of flow. The model allows for multiple waste discharges, water withdrawals, tributary flows and incremental inflows and outflows. The processes employed in QUAL2K address nutrient cycles, algal growth and DO dynamics. QUAL2K links plant respiration and photosynthesis as well as other oxygen demanding substances such as CBOD, the nitrification process (which uses oxygen to reduce organic nitrogen to NH_3 and then to NO_3+NO_2) and sediment demands of organic substances to instream oxygen levels.

Flow and water quality data collected on July 15 - 16, 2009, were used to calibrate the QUAL2K model for Piper Creek and data collected on August 19 - 20, 2009, were used to validate the models. Once the QUAL2K model was set up and calibrated for Piper Creek, a series of scenarios were run to evaluate the pollutant load reductions needed to achieve the minimum DO criterion. These results are summarized in Section 7 and a detailed discussion of the QUAL2K model is included in Appendix B.

7 CALCULATION OF LOADING CAPACITY

LC is defined as the greatest amount of a pollutant that a water body can assimilate without violating WQS. This load is then divided among the point source (WLA) and nonpoint source (LA) contributions to the stream, with an allowance for an explicit MOS. The MOS accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving water body. If the MOS is implicit, no numeric allowance is necessary. Conceptually, this definition is represented by the equation:

$$LC = \Sigma \text{ WLAs} + \Sigma \text{ LAs} + \text{MOS} \qquad \textbf{Equation 1}$$

Where:

LC =	Loading Capacity
WLA =	Wasteload Allocations (point source)
LA =	Load Allocations (nonpoint source)
MOS =	Margin of Safety (may be implicit and factored into a conservative WLA or LA or explicit)

The objective of the TMDL is to estimate allowable pollutant loads and to allocate these loads to known pollutant sources within the watershed so appropriate control measures can be implemented and the WQS can be achieved. The WLA and LA are calculated by multiplying the appropriate flow in cubic feet per second (cfs) by the appropriate pollutant concentration in milligrams per liter (mg/L). A conversion factor of 5.395 is used to convert to pounds per day (lbs/day).

Critical conditions are considered when the LC is calculated. DO levels that threaten the integrity of aquatic communities generally occur during low flow periods, so these periods are considered the critical condition. For Class P streams, mixing zones are applicable to all pollutants (with the exception of bacteria) that have specific criteria. Mixing zones are typically based on the 7-day average low flow of a stream with a recurrence interval of 10 years (7Q10) to account for critical low-flow conditions.

In the case of Piper Creek, a mixing zone of one-quarter (¼) of the stream width, cross-sectional area, or volume of flow and a length of ¼ mile is allowed. For modeling purposes, ¼ of the 7Q10 flow was used. The default 7Q10 for Class P streams is 0.1 cfs; thus a mixing zone flow of 0.025 cfs is appropriate for Piper Creek upstream of the facility. For DO targeting purposes, the 5 mg/L minimum DO criterion must be met at one-quarter mile below the facility outfall at 25 percent of the 7Q10 low flow to meet the mixing zone requirements. The applicable mixing zone regulation can be found at 10 CSR 20-7.031(4)(A)4.B.(II). The rationale for limiting the size of mixing zones is three-fold. First, the assumption of rapid and complete mixing is not a conservative assumption. Meaning, many times effluent plumes exist and cause areas of chronically toxic conditions that can extend laterally and longitudinally downstream. Second a zone of passage should be provided so that aquatic organisms may pass by facility outfalls without becoming adversely affected. Third, for antidegradation purposes, the entire assimilative capacity of the water body cannot be allocated to a single discharger.

The mixing zone extends one-quarter mile downstream of the facility and the LC must meet the DO target at the end of this section of the impaired segment. For modeling purposes, model runs were conducted at one-quarter of the 7Q10 low flow to assess LC values one-quarter mile downstream of the Bolivar WWTF and using 7Q10 low flow at distances further than a quarter mile from the Bolivar WWTF. The QUAL2K models predicted that the minimum DO concentration occurs within a quarter mile of the WWTF; thus, critical conditions are controlled by the one-quarter 7Q10 flow. Loads required to meet 5 mg/L DO under one-quarter of the 7Q10 flows were found to also achieve 5 mg/L DO at 7Q10 flows.

The QUAL2K model was calibrated using data collected on July 15 - 16, 2009, and validated using data collected on August 19 - 20, 2009. The August 19 - 20, 2009, models were used to identify the LC since this period represented more critical conditions (i.e., reduced DO and lower flows) than those present during the July 2009 monitoring events. The following steps were taken during the modeling process:

Step 1: Application of the Model to Existing Conditions

This application forms the current condition that is used to evaluate the magnitude of load reductions that are needed to meet WQS. Nonpoint source loads are set equal to the calibrated conditions.

Step 2: Application of the Model to Existing Conditions with Point Sources at Permit Limits

This application forms the baseline condition that will be reduced to meet the allowable load. The Bolivar WWTF was set at its permit limits using the permitted flow and mean daily concentration allowed for in the permit. For pollutants not included in the permit, the observed effluent data were used.

Step 3: Develop and Test Allocation Scenarios

Working from the baseline condition and considering the primary pollutant sources, sample allocation scenarios were developed and applied. For example, if existing BOD or nutrient effluent limits for the Bolivar WWTF in Step 2 are not protective of the instream DO WQS, the QUAL2K model is iteratively run at reduced BOD and nutrient concentrations until compliance with the WQS is met. The difference, between the baseline condition and BOD and nutrient WLA required to achieve the standard, is the percent reduction needed at the facility.

The TMDL, summarized in Table 9, is based on simulating one-quarter of 7Q10 flows in the model using the August 19, 2009, model results. The results are protective (e.g. DO > 5 mg/L) of the mixing zone at one-quarter the 7Q10 flow one-quarter mile downstream of the plant and in the entire impaired reach.

The modeling analysis indicates that a zero percent reduction in NH_3, a 82 percent reduction in BOD_5 load (from baseline conditions), a 50 percent reduction in SOD and increased effluent aeration to increase DO in the WWTF effluent concentrations to 5 mg/L are needed to achieve a minimum DO of 5 mg/L at locations downstream of the mixing zone.

BOD reductions are deemed necessary to achieve the SOD reduction because most of the SOD at the surface of the sediment is likely due to the biological decomposition of particulate organic material (including algae) discharged by the WWTF that settles downstream of the outfall. Bacterially facilitated nitrification of NH_3 is also a likely contributor to SOD.

To meet the targeted nutrient and TSS critical condition targets outlined in this TMDL, the sum of the WLA was calculated by using nutrient ecoregion reference concentrations, the 25th percentile EDU TSS concentrations and the sum of the design flows of permitted facilities in the watershed. The nonpoint sources or LA TMDL targets for TSS, TP and TN were calculated by using nutrient ecoregion reference concentrations, the 25th percentile EDU TSS concentrations and the sum of the headwater and tributary flows. For tributary loading, the ecoregion target for nitrogen (289 micrograms of Nitrogen per Liter [µgN/L] was assigned as 289 µgN/L in the organic nitrogen fraction, based on the assumption that, after implementing the TMDL, nitrogen from nonpoint sources would be largely represented by the organic nitrogen fraction. Similarly, for point source loading, the ecoregion target for nitrogen was assigned as 289 µgN/L ammonia, based on the assumption that ammonia is the primary parameter of concern, with respect to nitrogen, in treated WWTF effluent. For both point and nonpoint sources, the ecoregion criteria target for TP was split 70:30 between organic and inorganic phosphorus fractions[15], respectively, such that the organic phosphorus target was set equal to 4.9 µg/L and the inorganic phosphorus target was set equal to 2.1 µg/L. TP and TN nonpoint source baseline flow conditions were obtained using existing loads sampled on August 19, 2009. The LDCs for the targeted pollutants are depicted in Figure 7, Figure 8 and Figure 9, where the TMDL line represents the total LC of all point and nonpoint sources of pollutants. In these figures, the "Continuous WLA" includes the combined allocation for all five WWTFs that have a permitted design flow (city of Bolivar WWTF, Home Court Advantage, Inc. WWTF, Quail Creek Mobile Home Park WWTF, Silo Ridge Homeowners Association WWTF and Karlin Place Subdivision WWTF). The pollutant allocations under a range of flow conditions are presented in Table 10, Table 11 and Table 12.

[15] Under the natural conditions, a stream would have more organic phosphorus than dissolved phosphorus.

Table 9. TMDL Summary for Piper Creek at Critical Low Flows

Pollutant	Baseline Conditions (based on monthly average limits and design flow)			TMDL			WLA Percent Reduction	LA Percent Reduction
	Point Sources	Nonpoint Sources	Total	Point Sources (WLA)	Nonpoint Sources (LA)	Total		
Flow (cfs)	4.026	0.071	4.096	4.026	0.071	4.096	0	0
BOD_5 (lb/day)	654.9	1.4	656	120.5	0.5	121	82	63
$NBOD_{ult}$ (lbs/day)	No limit	2.8	Not applicable	136.8	1.0	137.8	Not applicable	65
NH_3 (lb/day)	30	0.2	30.2	30	0.1	30.1	0	42
TSS (lbs/day)	594	See Note	Not applicable	192	3	195	68	See LDC
TN (lbs/day)	No limit	1.1	Not applicable	6.3	0.1	6.4	Not applicable	See LDC
TP (lbs/day)	No limit	0.02	Not applicable	0.15	0.003	0.15	Not applicable	See LDC

Note: The WLA and LA specified in Table 9 results in a minimum DO of 5 mg/L and the effluent is aerated to at least 5.0 mg/L DO. Tributary and headwater nutrient concentrations are set to ecoregion criteria (TN = 0.289 mg/L and TP = 0.007 mg/L). Monthly average permit limits were used for baseline conditions. No TSS data is available in Piper Creek to calculate a baseline condition for nonpoint sources. Point and nonpoint baseline conditions for flow, BOD_5, $NBOD_{ult\ (ultimate)}$, NH_3, TN and TP are based on QUAL2K modeling results. The point source baseline condition for TSS is based on permitted flow and TSS concentration limits at the WWTFs. Point and nonpoint source TMDL limits for BOD_5, $NBOD_{ult}$ and NH_3 were obtained from QUAL2K model results. As discussed in Section 7, nitrogen target loading for point sources was based on setting ammonia equal to 289 µgN/L and nonpoint sources was based on setting organic nitrogen equal to 289 µgN/L. Point source TMDL limits are based on the sum of the site specific WWTFs

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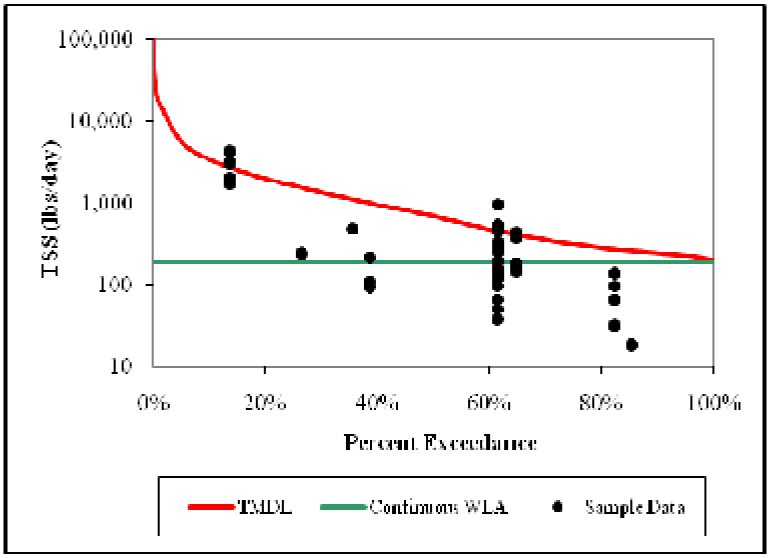

Figure 7. **TSS LDC for Piper Creek at Confluence of Piper Creek with the Pomme De Terre River**

Table 10. TSS TMDL Under a Range of Flow Conditions in Piper Creek

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA Rural (lbs/day)	LA Urban[2] (lbs/day)	WLA Bolivar WWTF (lbs/day)	WLA (other permits) (lbs/day)
95%	4.9	232.5	--	35.1	5.8	187.3	4.3
90%	5.2	248.4	--	48.7	8.1	187.3	4.3
70%	7.5	355.8	--	140.9	23.3	187.3	4.3
50%	14.8	702.8	--	438.6	72.6	187.3	4.3
30%	28.7	1,360.9	--	1,003.3	166.0	187.3	4.3
10%	72.3	3,434.6	--	2,782.5	460.5	187.3	4.3
5%	119.6	5,677.4	--	4,706.8	779.0	187.3	4.3

[1] The TSS MOS is implicit.
[2] LA is for low intensity urban area.

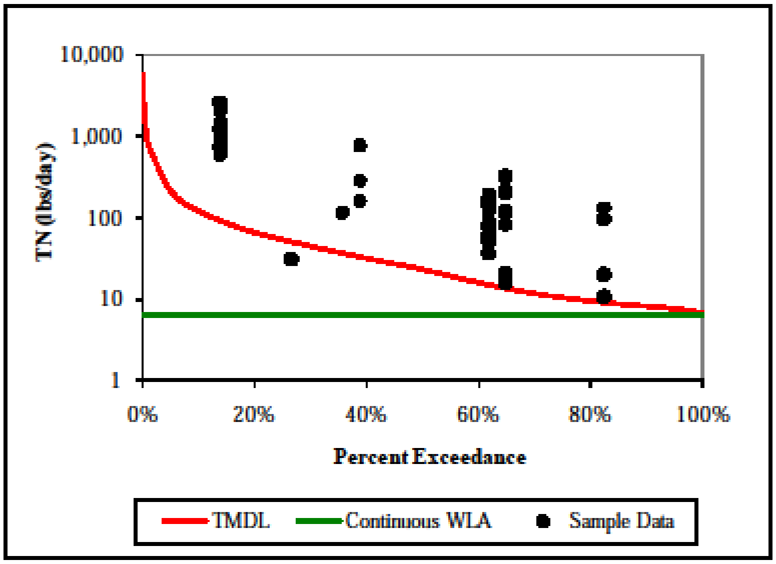

Figure 8. TN LDC for Piper Creek at Confluence of Piper Creek with the Pomme De Terre River

Table 11. TN TMDL Under a Range of Flow Conditions in Piper Creek

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA Rural (lbs/day)	LA Urban[2] (lbs/day)	WLA Bolivar WWTF (lbs/day)	WLA (other permits) (lbs/day)
95%	4.9	7.64	--	1.16	0.19	6.15	0.14
90%	5.2	8.16	--	1.60	0.27	6.15	0.14
70%	7.5	11.68	--	4.63	0.76	6.15	0.14
50%	14.8	23.08	--	14.40	2.39	6.15	0.14
30%	28.7	44.69	--	32.95	5.45	6.15	0.14
10%	72.3	112.79	--	91.38	15.12	6.15	0.14
5%	119.6	186.45	--	154.58	25.58	6.15	0.14

[1] The TN MOS is implicit.
[2] LA is for low intensity urban area.

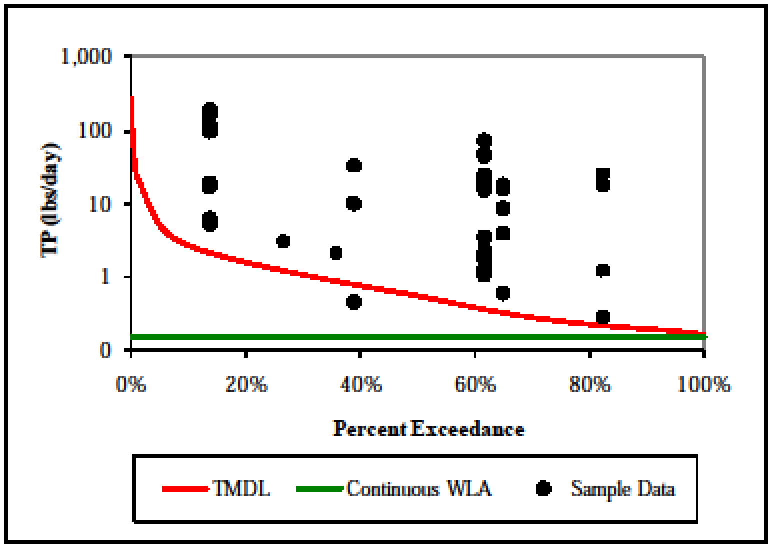

Figure 9. TP LDC for Piper Creek at Confluence of Piper Creek with the Pomme De Terre River

Table 12. TP TMDL Under a Range of Flow Conditions in Piper Creek

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA Rural (lbs/day)	LA Urban[2] (lbs/day)	WLA Bolivar WWTF (lbs/day)	WLA (other permits) (lbs/day)
95%	4.9	0.18	--	0.03	0.00	0.15	0.003
90%	5.2	0.20	--	0.04	0.01	0.15	0.003
70%	7.5	0.28	--	0.11	0.02	0.15	0.003
50%	14.8	0.56	--	0.35	0.06	0.15	0.003
30%	28.7	1.08	--	0.80	0.13	0.15	0.003
10%	72.3	2.73	--	2.21	0.37	0.15	0.003
5%	119.6	5.05	--	4.21	0.69	0.15	0.003

[1] The TP MOS is implicit.
[2] LA is for low intensity urban area.

8 WASTE LOAD ALLOCATION (POINT SOURCE LOADS)

The WLA is the portion of the LC that is allocated to existing and/ or future point sources of pollutants. The sum of design flows of all site specific permitted dischargers with NPDES Permits (Table 7) in the Piper Creek watershed, excluding permitted storm water flows, is 2.61 MGD.

New WLAs for the city of Bolivar WWTF were calculated through the modeling process and are shown in Table 13. The WLA for BOD_5 and NH_3 were derived from the QUAL2K modeling that resulted in meeting WQS. The WLAs for TN, TP and TSS were derived from the LDCs at low flow, when inputs are set at the facility design flow of 3.95 cfs (2.55 MGD). The other permitted facilities in the watershed each discharge an insignificant volume of effluent compared to the city of Bolivar WWTF, and are unlikely to discharge during the critical low flow periods. Their WLAs therefore remain equal to existing permit limits, which are summarized in Table 14, for the facilities with individual, site specific permits.

Table 13. WLAs for City of Bolivar WWTF (MO0022373) in the Town Branch/ Piper Creek Watershed

Effluent Parameter	Design Flow (MGD)	Existing Permit Limit		WLA at Design Flow based on QUAL2K modeling		Percent Reduction
		Concentration (mg/L)	Load (lbs/day)	Concentration (mg/L)	Load (lbs/day)	
$CBOD_5$	2.55	No limit	No limit	4.03	86	Not applicable
$NBOD_5$	2.55	No limit	No limit	1.17	25	Not applicable
TN	2.55	No limit	No limit	0.289	6.17	Not applicable
TP	2.55	No limit	No limit	0.007	0.15	Not applicable
NH_3	2.55	Daily Maximum = 3.7[16] - 8.1[17] Monthly Average = 1.4[18] - 3.1[19]	30	1.4	30	0
TSS	2.55	Weekly Average = 41 Monthly Average = 27	575	27	575	0

Notes: $CBOD_5$ is calculated using simulated BOD_5 divided by 1.29, based on 1998 EPA modeling guidance for NH3 toxicity and DO modeling. $NBOD_5$ is the difference between BOD_5 and $CBOD_5$. TN target loading for point sources was based on 289 µgN/L, Ecoregion 39 TN value. TP target loading for point sources was based on 7 µgP/L, Ecoregion 39 TP value.

[16] Represents limits from May 1 – October 31
[17] Represents limits from November 1 – April 30
[18] Represents limits from May 1 – October 31
[19] Represents limits from November 1 – April 30

Table 14. Existing TSS Permit Limits for Four Small WWTFs in the Town Branch/Piper Creek Watershed

Facility ID	Facility Name	Design Flow (MGD)[1]	Existing TSS Permit Limits Concentration (mg/L)	Load (lbs/day)[2]
MO0097594	Home Court Advantage, Inc. WWTF	0.007	Weekly Average = 45 Monthly Average = 30	1.75
MO0116467	Quail Creek Mobile Home Park WWTF	0.01395	Weekly Average = 110 Monthly Average = 70	8.15
MO0121754	Silo Ridge Homeowners Association WWTF	0.01683	Weekly Average = 45 Monthly Average = 30	4.21
MO0121924	Karlin Place Subdivision WWTF	0.021	Weekly Average = 45 Monthly Average = 30	5.26

[1] MGD = Million Gallons per Day
[2] Existing TSS permit limit loads (lbs/day) are based on existing design flow and monthly average limits

9 LOAD ALLOCATION (NONPOINT SOURCE LOADS)

The LA includes all existing and future nonpoint sources and natural background contributions (40 CFR § 130.2(g)). The LA for the Piper Creek TMDL is for all nonpoint sources of $CBOD_5$, NBOD, TSS, TP and TN, which could include loads from agricultural lands, runoff from urban areas, livestock and failing onsite wastewater treatment systems. The LA also includes runoff from the city of Bolivar, Missouri. The LAs, provided in Table 9, Table 10, Table 11 and Table 12, were calculated based on the total of all headwater and lateral inflow loads used in the QUAL2K model for the allocation scenario model run and LDCs. The LA is intended to allow the DO target to be met at all locations within the stream.

10 MARGIN OF SAFETY

A MOS is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems. The MOS is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the MOS can be achieved through one of two approaches:

1) Explicit - Reserve a numeric portion of the LC as a separate term in the TMDL.
2) Implicit - Incorporate the MOS as part of the critical conditions for the WLA and LA calculations by making conservative assumptions in the analysis.

An implicit MOS was incorporated into the CBOD and NH_3 TMDLs by identifying a LC that achieves a minimum DO concentration of 5 mg/L at the 7Q10 low flow by using conservative modeling assumptions within QUAL2K. The conservative modeling assumptions used for the implicit MOS in the QUAL2K model calibration focused on measured low DO concentrations, critical low flow conditions and DO concentrations under critical low flow conditions in deriving applicable BOD, CBOD, NBOD, NH3 and TSS targets for the city of Bolivar WWTF.

For TSS, TN and TP, an implicit MOS was incorporated into the TMDL based on conservative assumptions used in the development of the TMDL LDCs. Among the conservative approaches used was to calculate WLAs by targeting the 25th percentile of TSS concentrations in the geographic region in which Piper Creek is located. Another conservative approach was to establish WLAs for the city of Bolivar WWTF under critical low flow conditions when discharge from this facility will dominate the stream flow. The TN and TP targets for this TMDL are also conservative because they are based on the 25th percentile of all TN and TP data gathered from the Subecoregion 39 of Aggregate Nutrient Ecoregion IX. These targets were derived by EPA to represent conditions of surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses (EPA, 2000). The 25th percentile is considered a surrogate for establishing a reference population of the pristine systems (EPA 2000).

11 SEASONAL VARIATION

A TMDL must consider seasonal variation in the derivation of the allocations. DO levels that threaten the integrity of aquatic communities generally occur during low flow periods and warm temperatures, so these periods are considered the critical condition for the DO target. Annual low-flow conditions in Missouri typically occur between July 1 and September 15. In this TMDL report, summer low flow is defined as a 7-day average flow of the 10-year return frequency (7Q10) dry-weather condition. This TMDL addresses seasonal variation and critical conditions by identifying a LC that would be protective of the DO target during the 7Q10 low flow period.

DO in streams is affected by several factors including water temperature, the amount of decaying matter (i.e., organic sediment) in the stream, turbulence at the air-water interface and the amount of photosynthesis occurring in plants within the stream. Organic sediments and SOD can also contribute to fluctuating DO concentrations in the water column. The effects of high nutrient and BOD concentrations on DO swings and low DO conditions (discussed in Section 5.2) are typically amplified under circumstances in which flow is low and water temperature is relatively high (for example, summer months).

The TMDL LDCs for TSS, TN and TP represents flow under all conditions. Because the WLA, LA and TMDL are applicable at all flow conditions, they are also applicable and protective over all seasons. The advantage of the LDC approach is that all flow conditions are considered and the constraints associated with using a single-flow critical condition are avoided.

12 MONITORING PLAN

TMDL monitoring will be scheduled by MDNR after new effluent limits in the city of Bolivar WWTF permit has gone into effect in 2011 (ammonia) and 2012 (bacteria). In addition, in-stream monitoring is required by the Bolivar WWTF permit as follows: Two sites, one upstream and one downstream of the WWTP outfall, will be sampled quarterly for DO, TSS, TP and TN. Also, the local watershed group monitors eight sites three times a year. Trained stream team volunteer water quality monitors gather and submit these data to MDNR on a regular basis.

In addition, MDNR will routinely examine physical habitat, water quality, invertebrate and fish community data collected by the Missouri Department of Conservation under its Resource Assessment and Monitoring (RAM) Program. This program randomly samples streams across Missouri on a 5- to 6-year rotating schedule.

As with all of Missouri's TMDLs, if continuing monitoring reveals that WQSs are not being met, the TMDL will be reopened and re-evaluated accordingly.

13 REASONABLE ASSURANCES

MDNR has the authority to issue and enforce Missouri State Operating Permits. Inclusion of effluent limits into a state operating permit and requiring that effluent and instream monitoring be reported to MDNR should provide reasonable assurance that instream WQS will be met. Section 301(b)(1)(C) requires that point source permits have effluent limits as stringent as necessary to meet WQS. However, for WLAs to serve that purpose, they must themselves be stringent enough so that (in conjunction with the water body's other loadings) they meet WQS. This generally occurs when the TMDL's combined nonpoint source LAs and point source WLAs do not exceed the WQS-based LC and there is reasonable assurance that the TMDL's allocations can be achieved. Any discussion of reduction efforts relating to nonpoint sources would be found in the implementation section of the TMDL.

14 PUBLIC PARTICIPATION

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). EPA is providing public notice of this draft TMDL for Piper Creek (Town Branch) on the EPA, Region 7, TMDL website: http://www.epa.gov/region07/water/tmdl_public_notice.htm. The response to comments and final TMDL will be available at: http://www.epa.gov/region07/water/apprtmdl.htm#Missouri.

This water quality limited segment of Piper Creek (Town Branch) in Polk County, Missouri, is included on the EPA-approved 2008 303(d) List for Missouri. This TMDL is being established by EPA to meet the requirements of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001. EPA is developing this TMDL in cooperation with the state of Missouri and EPA is establishing this TMDL at this time to meet the *American Canoe* consent decree milestones. Missouri may submit and EPA may approve a revised or modified TMDL for this water at any time.

Before finalizing EPA established TMDLs (such as this TMDL), the public is notified that a comment period is open on the EPA Region 7 website for at least 30 days. EPA's public notices to comment on draft TMDLs are also distributed via mail and electronic mail to major stakeholders in the watershed or other potentially impacted parties. After the comment period closes, EPA reviews all comments, edits the TMDL as is appropriate, writes a Summary of

Response to Comments and establishes the TMDL. For Missouri TMDLs, groups receiving the public notice announcement include a distribution list provided by MDNR, the Missouri Clean Water Commission, the Missouri Water Quality Coordinating Committee, stream team volunteers, state legislators, County Commissioners, the County Soil and Water Conservation District and potentially impacted cities, towns and facilities. EPA followed this public notice process for this TMDL. Links to active public notices for draft TMDLs, final (approved and established) TMDLs and Summary of Response to Comments are posted on the EPA website: http://www.epa.gov/region07/water/tmdl.htm.

15 ADMINISTRATIVE RECORD AND SUPPORTING DOCUMENTS

An administrative record on the Piper Creek (Town Branch) TMDL has been assembled and is being kept on file with EPA.

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Appendix B

Detailed Information Regarding Reduction Items and Best Management Practices

Reduction Actions

1. Future Development			
Practice	Financial Assistance	Cooperators	Comments
Establishment of a comprehensive plan for the city of Bolivar.	Planning phase is currently funded.	City of Bolivar, Community Partners	Currently being implemented. Expected completion date is in 2012.
Upgrading and maintaining the storm water infrastructure system.	Funding options are currently being researched.	City of Bolivar, BCWIG, Community Partners	Bolivar will be complying with the NPDES requirements since its population exceeded 10,000 residents in 2010. It can be expected that this planning and implementation process will take a while before the program is established.
Increase the amount of open space and establish a greenway trail system.	Funding options are currently being researched.	City of Bolivar, Community Partners	Though a long term goal, this can be a part of the comprehensive plan for the city of Bolivar. Greenway trail systems are typically sited in floodplain areas which are susceptible to flooding. They not only provide recreational, health and alternative transportation benefits, but also help in protecting water quantity and quality conditions.

2. Storm Water Infrastructure		
Practice	Cooperators	Comments
Establish a Storm Water Steering Committee	City of Bolivar and Community Groups	Due to the City of Bolivar complying with NPDES requirements to address storm water runoff -a local storm water steering committee should be organized to research, develop and evaluate options for establishing, maintaining and funding a storm water management program.
Implement Storm Water Program	City of Bolivar, Storm Water Steering Committee, Community Groups (*Homebuilder's Association*, *Downtown Association,*	Through the NPDES process, certain ordinances may have to be implemented in order to address storm water runoff.
Promote the disconnection of impervious area	City of Bolivar and BCWIG	This method promotes the establishment of grassed buffers, swales, bio-retention cells and opens space between areas of impervious areas (such as parking lots, concrete drainage ways, etc.). These practices will be explained in the further section.
Upgrade and maintain storm water facilities.	City of Bolivar	Storm water facilities such as detention basins, inlet/outlets, drainage ways and other BMPs will need to be established, upgraded and maintained in order to sustain their effectiveness.
Promote the establishment of a city-wide Hazardous Household Recycling Program	City of Bolivar, Polk County, Polk County Health Department, BCWIG and Community Groups	The establishment of a hazardous household recycling program will help citizens to properly dispose of

City of Bolivar-Storm Water Steering Committee

(Plan of Action & Rationale)

Purpose

The Storm Water Committee is an advisory group formed to research, review, discuss and comment on the establishment of a storm water program. Since the Engineering Department is responsible for implementing the components of the Phase II NPDES requirements, all action plans will be researched and drafted by staff and presented to the Committee for discussion, direction and approval. The Storm Water Committee should meet once a month or every other month during the first year. Meetings should last up to an hour and a half at the most.

The purpose of the Storm Water Committee will be to:

1. To provide guidance and direction (comments, ideas, critiques) during the development of the Bolivar Storm Water Management Program.

2. To advocate and recommend to City Council applicable ordinances and programs that will need Council review, discuss and consider for approval.

3. To support and disseminate the purpose and activities of the Storm Water Management Program to the local community and decision makers.

Requirements for NPDES Program

The federal Clean Water Act requires that storm water discharges from certain types of facilities be authorized under storm water discharge permits. The goal of the storm water permits program is to reduce the amount of pollutants entering streams, lakes and rivers as a result of runoff from residential, commercial and industrial areas.

Water pollution degrades surface waters making them unsafe for drinking, fishing, swimming, and other activities. As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

The Stormwater Phase II Final Rule (December 8, 1999) requires operators of regulated small municipal separate storm sewer systems (MS4s) to obtain a National Pollutant Discharge Elimination System (NPDES) permit and develop a stormwater management program designed to prevent harmful pollutants from being washed by stormwater runoff into the MS4 (or from being dumped directly into the MS4) and then discharged from the MS4 into local waterbodies.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Phase II (Stormwater) Requirements

1. PUBLIC EDUCATION AND OUTREACH

   Purpose: To make the public aware of stormwater and its impacts.

   - Implement a public education program for the community regarding stormwater runoff.
   - Targeting local business regarding impacts and practices to deter such impacts.

2. PUBLIC PARTICPATION/INVOLVEMENT

   Purpose: To involve the community in voluntary result-oriented activities.

   - Facilitate public meetings for citizen input and comments regarding stormwater.
   - Facilitate citizen groups in community based projects.

3. ILLICIT DISCHARGE DETECTION AND ELIMINATION

   Purpose: To identify stormwater sources and standardize proactive actions.

   - Develop a storm sewer system map.
   - Develop a storm water ordinance.
   - Enlighten public employees, business and citizens on disposal practices.

4. CONSTRUCTION SITE STORM WATER RUNOFF CONTROL

   Purpose: To standardize the control of sediment and erosion.

   - Develop a construction sediment and erosion control ordinance.
   - Facilitate educational seminars for developers, contractors and engineers.

5. POLLUTION PREVENTION/GOOD HOUSEKEEPING

   Purpose: To demonstrate municipal involvement.

   - Implement programs for municipal-based operations.
   - Provide employee training.

Disconnection of Impervious Areas

General Description

Runoff from connected impervious surfaces commonly flows directly to a stormwater collection system with no possibility for infiltration into the soil. For example, roofs and sidewalks commonly drain onto roads, and the runoff is conveyed by the roadway curb and gutter to the nearest storm inlet. Runoff from numerous impervious drainage areas may converge, combining their volumes, peak runoff rates, and pollutant loads. Disconnection decouples roof leaders, roadways and other impervious areas from stormwater conveyance systems, allowing runoff to be collected and managed on site or dispersed into the landscape. Runoff is redirected onto pervious surfaces such as vegetated areas, reducing the amount of directly connected impervious area and potentially reducing the runoff volume and filtering out pollutants.

Water Quantity Controls

Routing runoff to vegetated areas will reduce the peak discharge and stormwater volume by providing an opportunity for infiltration and evapotranspiration. The potential exists for runoff to be completely taken “out of the system” by spreading it out and infiltrating it over pervious surfaces and BMPs. The impact of disconnection on stormwater volume and peak discharge is dependent upon the area to which the stormwater is directed. Disconnection can also reduce the calculated peak discharge rate by increasing the time of concentration. Lower runoff velocities will result in greater contact time with the soil, potentially increasing the runoff volume lost to infiltration. Factors influencing runoff velocity include slope and surface roughness. Decreasing the slope and increasing surface roughness will reduce the runoff velocity. The time of concentration can also be increased by increasing the length of the flow paths; for instance, by increasing circuitousness.

Water Quality Controls

Water quality benefits are gained from disconnection practices because a percentage of the overall stormwater volume infiltrates into pervious areas or is lost through evapotranspiration. Pollutant load from impervious areas is a product of pollutant concentration and the stormwater volume. Disconnection practices decrease the total volume of stormwater discharged to receiving water bodies. Therefore, the reduction in pollutant and nutrient loading attributed to disconnection is dependent upon the reduction in stormwater volume.

Location

Disconnection practices may be applied in almost any location, but impervious surfaces must discharge into a suitable receiving area for the practices to be effective. Runoff must not flow toward building foundations or onto adjacent private property. Typical receiving areas for disconnected impervious runoff include vegetated BMPs (e.g. filter strips or bioretention) and other existing landscaping such as shrubs.

Design Construction and Materials

Disconnecting impervious areas requires little construction and few materials. Rooftop disconnection will require minimal modification to the downspouts to redirect runoff away from the collection system or other impervious areas. Various other methods are available to disconnect impervious areas, but typical procedures may include curb cuts to encourage stormwater flows away from inlets and open area modifications to enhance the infiltration characteristics of receiving areas. Other modifications include flow spreading and leveling devices, which may be used to encourage shallow sheet flow through vegetated areas. Soil amendments to increase soil permeability are also a possible design option.

Cost

Disconnecting impervious areas is a management technique and does not require maintenance costs as with other BMPs. Disconnecting roof leaders, for example, requires simple modifications typically costing $100 or less. There is generally assumed to be little cost associated with implementing a disconnection program.

Maintenance

Related maintenance activities are primarily focused on the areas designated to receive stormwater runoff. Engineering infiltration areas should be routinely checked to ensure that they are free of debris and trash. Both vegetated and constructed infiltration areas should be inspected for sediment accumulation. Additionally, receiving areas should be inspected for signs of channelized flow and signs of compaction.

Performance and Inspection

Disconnection practices may require annual inspection to ensure that the stormwater is still directed to the desired location. Requirements to measure performance are minimal.

Hazardous Household Recycling

Purpose

The goal of implementing a hazardous household recycling program is to recycle, reuse, or properly dispose of materials that are often improperly disposed of in municipal landfills or waste water treatment systems. Everyday disposal of household products are often overlooked as impairing local water ways. Properly disposing of hazardous household materials will help to protect the safety of citizens while protecting the environment.

Example of Hazardous Household Materials

The following are a list of various materials found throughout the houses and businesses that can significantly impair the water quality of streams (if so improperly disposed):

Automotive products (antifreeze, auto or marine batteries, brake fluid, car wax and cleaners, gasoline, oil filters, transmission fluid, windshield washer fluid)

Pesticides (disinfectant, flea collars, insect repellant, insecticide, mothballs, pet spray and dip, rat and mouse poison, weed killer)

Household cleaners (drain opener, furniture polish and wax, oven cleaner, spot remover, toilet bowl cleaner, tub and tile cleaner)

Other (aerosol cans, art and craft materials, cosmetics, lighter fluid, pool chemicals, shoe polish, fluorescent lamp ballasts (tubes) and compact fluorescent bulbs)

Home improvement products (adhesives, caulk, oil-based paint, paint thinner, stain, varnish)

Pharmaceutical products (prescription, non-prescription medicine/pills, veterinary supplies)

Computer and Television products (these products contain mercury and other heavy metals)

Means of Proper Disposal

Hazardous Household Recycling Center

- Many municipalities have funded hazardous household recycling centers that educate citizens on the need of recycling these products while providing them a center to drop off their unused products for free or for a small fee. These centers are typically operated on a daily or weekly basis. Appoints have to be made for security purposes. The material that is usually collected is recycled or disposed of by contracted businesses.

City-Wide Collection Events

- Another method is to have a city-wide collection day (typically twice a year) where citizens can drop off their products at certain drop-off locations where municipal employees help with sorting and stockpiling material for latter contracted transport and disposal. This method is typically less costly and is used for smaller populated municipalities.

3. Waste Water Infrastructure			
Practice	**Financial Assistance**	**Cooperators**	**Comments**
Continue to comply with the NPDES permit and policy.	Funding is currently being provided by the City of Bolivar for such compliance	City of Bolivar	The City of Bolivar continues to comply with NPDES policy and intends to upgrade its facility by installing a disinfection system and any other future requirements.
Convert and decommission existing residential on-site wastewater systems (septic tanks) to the municipal waste water system.	The primary responsibility is that of the landowners.	City of Bolivar, Polk County Health Department	Converting on-site waste water residences to the municipal system will ensure that waste water treatment is more centralized and manageable.

The Bolivar Municipal Waste Water Treatment facility is a permitted NPDES site that treats waste water before releasing its effluent into Town Branch. The city performs monthly water quality tests on Town Branch as part of its NPDES requirement. It also maintains and performs upgrades to its treatment and collection systems on a continual basis in order to ensure infrastructural reliability. The treated effluent that is released from this facility complies with the all requirements and water quality standards as set forth through the Missouri Department of Natural Resources.

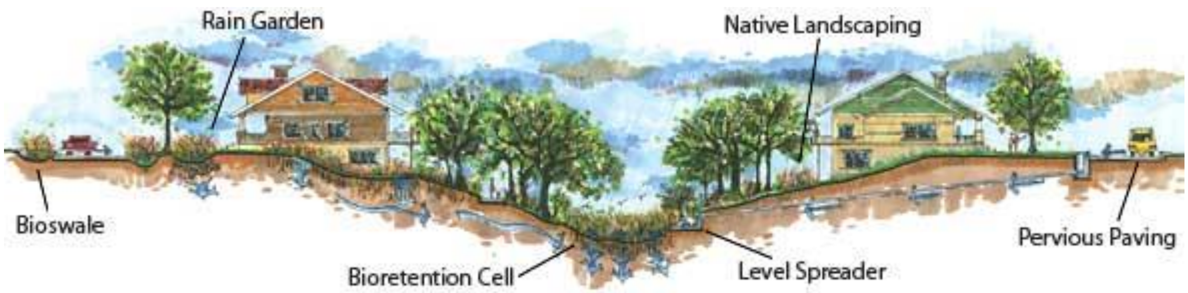
4. Residential/Commercial BMPs			
Practice	Financial Assistance	Cooperators	Comments
Promote Low Impact Development (LID) design techniques	Potential grants	BCWIG, City of Bolivar, NRCS	This method incorporates different practices such as bioswales, rain gardens, bioretention cells, pervious pavements, level spreading, etc.
Promote proper lawn fertilization techniques	Potential grants	BCWIG, NRCS	This method was designed to provide landowners the proper guidance in fertilizing and caring for their yard by calculating the exact nutrient and fertilizer requirements in the form a conservation plan.
Promote rainwater detention use	Potential grants	BCWIG, City of Bolivar, NRCS	Rainwater can be detained for future use (such as watering, irrigation and fire protection) through many different practices such as rain barrels, cisterns and underground tanks.

Low Impact Development (LID)

General Description

Low Impact Development (LID) is a stormwater management strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution. LID comprises a set of site design approaches and small-scale stormwater management practices that promote the use of natural systems for infiltration, evapotranspiration, and reuse of rainwater. These practices can effectively remove nutrients, pathogens, and metals from stormwater, and they reduce the volume and intensity of stormwater flows.

The LID Approach to Storm Water Management



Bioswale
Bioswales are storm water conveyance features that slowly convey water to storm sewer inlets or surface waters and filter the “first flush” of runoff.

Rain Garden
Rain gardens are native, perennial gardens strategically located to capture runoff from impervious surfaces. Rain gardens increase aesthetic value, absorb water, reduce runoff, protect water quality, and prevent flooding.

Bioretention Cell
Bioretention cells are shallow, landscaped depressions that can handle large volumes of water. They are well-suited for commercial, institutional, or residential settings. Bioretention cells have an engineered base to offset compacted soil conditions.

Level Spreader
Level spreaders are flat areas constructed to slow runoff. They dissipate water velocity and prevent erosion by spreading water flows over a wide area, rather than releasing them from a point source of discharge, such as a pipe.

Native Landscaping
Native plants have a tremendous root structure that builds soil quality and increases organic matter content to facilitate infiltration.

Pervious Paving
Pervious paving surfaces may include permeable paver blocks, porous concrete, or porous asphalt. They provide the support of traditional parking surfaces, but they allow a significant amount of annual precipitation to be filtered.

KEY PRINCIPLES AND BENEFITS OF LOW IMPACT DEVELOPMENT (LID)

ENVIRONMENTAL PROTECTION

Natural features, such as wetlands, woodlands, and stream buffers are protected. By preserving these features, natural drainage patterns can be identified and used as green infrastructure, biodiversity is retained, and wildlife habitat is protected.

STORM WATER MANAGEMENT

Rather than flowing off site, water is directed to infiltration based storm water management practices and absorbed on site. Keeping water on site reduces pollutant loads, moderates peak stream flow rates and volume, and enhances base flows.

COMMUNITY CHARACTER

In residential settings, homes typically open up to open space and feature recreational trails. Native landscaping provides aesthetic value, adequate storm water conveyance, distribution of water flow, and filtration of pollutants.

BENEFITS OF LOW IMPACT DEVELOPMENT

TO RESIDENTS:

- increases community character
- improves quality of life
- increases open space
- promotes pedestrian-friendly landscaping

TO DEVELOPERS:

- reduces land clearing and grading costs
- reduces infrastructure costs (streets, curbs, gutters, sidewalks)
- increases lot values and community marketability

TO COMMUNITIES:

- balances growth needs with environmental protection
- reduces infrastructure and utility maintenance costs

TO THE ENVIRONMENT:

- protects environmentally-sensitive areas
- increases wildlife habitat by preserving trees and vegetation
- protects water quality by reducing pollutant loads
- reduces stream bank and channel erosion by reducing peak flows and moderating the frequent bounce associated with lower intensity storms
- reduces flooding potential

Reference: Montana NRCS

Low Impact Development (LID)

Homeowner Benefits

- Reduced flooding – onsite stormwater management reduces downstream flooding. A marginal reduction in flooding increases floodplain property values by up to 5%.
- Reduced cooling costs – reduced pavement and increased natural vegetation reduced home energy bills by 33-50% compared to surrounding neighbor-hoods in Davis CA.
- Increased amenity values – a preliminary analysis concluded that Seattle's BMP retrofitted "greenstreets" added 6% to the value of properties.
- Significant improvement in water quality can increase market value by 15% for properties bordering the water body.
- Reduced stormwater fees if local government charges fees based on impervious surface.
- Reduced cooling needs because more trees and green space are retained.

Local Government Benefits

- Protecting water quality helps protect real estate values, which protects tax revenues.
- Reduced inflow and infiltration – less stormwater leaking into sanitary sewers means less volume of water reaching sewage treatment plant.
- Reduced filtration costs – bioretention instead of piped stormwater and sand filters saved $250,000 along Anacostia River in Washington, DC.
- Reduced public expenditures on stormwater infrastructure including expensive retrofits.
- Reduced system-wide operations and maintenance costs of pipe infrastructure.
- Extension of the useful life of central pipe infrastructure as populations increase.
- Reduced regulatory costs associated with water-quality impacts, such as threats to sensitive species, TMDL compliance, etc.

Benefits to Developers

- Increased number of buildable lots – reducing the need for stormwater retention ponds may result in more lots available for homesites.
- Less spent on infrastructure - replacing curb, gutter, and storm sewers with roadside swales saved one developer $70,000 per mile, or $800 per residence.
- Increased property values – lots in LID neighborhoods sold for $3000 more than lots in competing areas not using LID.
- Initial savings from LID are usually accomplished through less conventional stormwater infrastructure, less paving, and lower site preparation costs.

Benefits to the Community

- Protecting natural ecosystems through sound LID practices provides benefits to communities such as: reduced flooding, improved water quality, increased groundwater recharge, improved air quality, enhanced aesthetics, enhanced property values, increased open space, and carbon sequestration. These are all **ecosystem services.**
- Protecting water quality through LID maintains the value of clean water, which is usually less expensive than cleaning contaminated water. Not having to clean contaminated water is an **avoided cost**.
- Clean water is a quality of life benefit: although difficult to quantify, its value may rival or exceed more tangible benefits. For example, protecting human health is the driving force behind the nation's water supply protection program.
- Reduced flooding, reduced stream erosion, and reduced pollutant loading to downstream waters.

Reference: North Carolina Cooperative Extension

USDA NRCS
Natural Resources Conservation Service

South Missouri
Water Quality Project

Nutrient Management Plans for Lawns

Proper fertilization is essential for a healthy lawn. Applying the correct type and amount of fertilizer also protects water quality.

Purpose

The purpose of Nutrient Management Plans for Lawns is to provide the homeowner information on the correct ***type*** and ***amount*** of fertilizer for their lawn.

How?

The South Missouri Water Quality Project provides ***free*** technical services in identifying the correct fertilizer that needs to be applied to your lawn.

Upon a request from the landowner, a staff member from the South Missouri Water Quality Project will:

1. Meet with the landowner (you).
2. Measure your yard.
3. Take a soil sample from your yard*.
4. Analyze results of your soil sample.
5. Recommend the proper type and amount fertilizer to be applied.
6. Write a 4-year fertilization plan.
7. Meet and explain the plan with you.

*The soil sample analysis is performed by University Missouri Extension for a fee of $15.00.

For more information or to schedule an appointment, contact the South Missouri Water Quality Project at (417) 581-2719 ext. 5.

RAINWATER HARVESTING

Rainwater Harvesting

Rainwater harvesting is the practice of collecting and using rainwater from hard surfaces such as roofs. It is an age-old technology; communities in ancient Rome were designed with individual cisterns and paved courtyards, which captured rainwater to augment supply from the city's aqueducts. Today, rainwater harvesting is growing in popularity as people look for ways to use water resources more wisely.

Many rural areas around the world rely on rainwater as their primary water source, but areas served by municipal water have tended to overlook rainwater as a water resource.

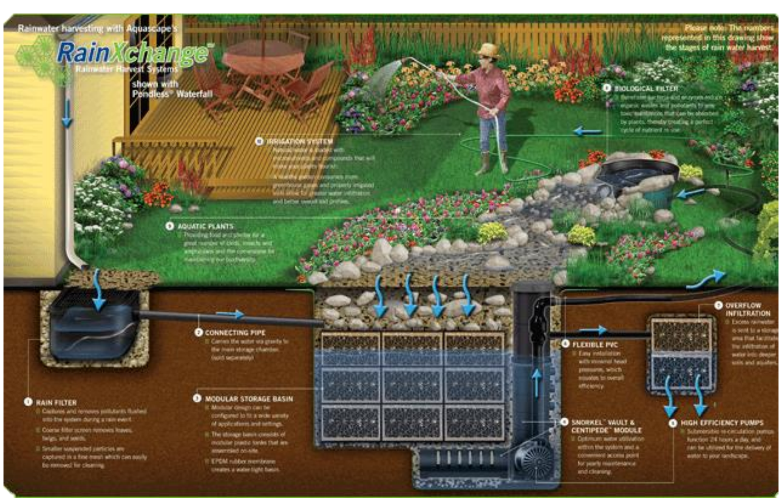
Why Harvest Rainwater?

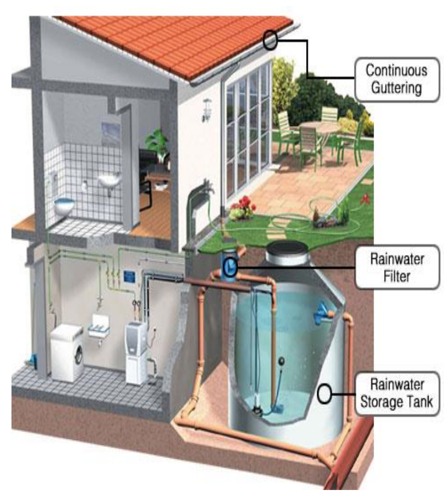
By harvesting rainwater you:

- Keep relatively clean water out of the sewer system and make it available for use;
- Reduce the energy and chemicals needed to treat stormwater in wastewater plants, and the energy expended transporting water from far away;
- Reduce the volume and peak flows of stormwater entering the sewer, thereby helping to reduce flooding and combined sewer discharges; and
- Reduce the volume of potable water used for non-potable applications such as irrigation, garden watering and fire protection.

Making it Happen

Rainwater can be harvested from most types of rooftops. The first steps are to clean your roof, disconnect your downspout from the sewer, and connect it to a storage container. Rainwater harvesting can retain up to 100% of roof runoff on site during small rain storms. In larger storms, water in excess of the system's storage capacity is discharged to the combined sewer or stormwater facility.





Rain Barrels

Rain barrels are containers designed to capture rainwater runoff from your roof so that you can use it for irrigation or other non-potable applications. Rain barrels are inexpensive, easy to install and maintain, and well suited to small-scale residential sites. They typically range from 50 to 100 gallons, and the water they collect is most often used to water plants.

System components

A rain barrel should have a spigot and/or hose so that you can access the water, an overflow pipe, a sealed and screened lid with an opening to attach your downspout, and screens on all vents.



Cisterns

Cisterns are larger than rain barrels, ranging from 100 gallons on a small residential site to millions of gallons beneath schools and parks. They can be installed above or below ground, or even on the roof, depending upon site conditions. Water from cisterns can be stored until needed and used for irrigation and toilet flushing.

System components

Cistern systems vary in size and complexity depending on the end use of the rainwater and the site constraints.

Cisterns not connected to indoor plumbing

A basic system used for irrigation typically includes fully screened gutters, downspouts, and piping; a fully closed storage tank; a spigot and/or hose for access; and an overflow pipe.

Cisterns connected to indoor plumbing for toilet flushing

A system designed to provide water for toilet flushing has more detailed specifications. It should have non-toxic, fully screened gutters, downspouts, and yellow piping; an automatic self-draining first flush diverter; a fully closed storage tank approved for use with potable water (even if water is used for irrigation and toilet flushing only); an approved backflow prevention device and an air gap; a spigot and/or hose for access; and an overflow pipe.



5. Town Branch Attributes			
Practice	Financial Assistance	Cooperators	Comments
Promote stream restoration practices and projects	Potential grants	BCWIG, City of Bolivar, NRCS, Missouri Department of Conservation	There are various methods of restoring degraded, incised and eroded streams. This may include incorporating hard armoring - practices with natural vegetative techniques.
Promote trash and debris deterrence methods	Potential grants	BCWIG, City of Bolivar, Polk County	Trash and debris flow is a major issue in protecting waterways. There are many structural and non-structural BMPs that could be employed to deter such pollution. Examples include holding community stream clean-ups, advocating current and future recycling programs and promoting new inlet protection and maintenance practices.
Incorporate water quality control measures with flood control practices such as detention basins.	Potential grants	BCWIG, City of Bolivar, NRCS	This would tie in with previous recommended practices such as Low Impact Development practices as well as the City of Bolivar's Stormwater Management program. Though detention basins are designed for flood control, they could easily be designed for water quality control as well.

STREAM RESTORATION PRACTICES

Stream restoration practices have a range of objectives, from bank protection to habitat creation. Frequently, these practices are installed in concert with upstream stormwater management practices.

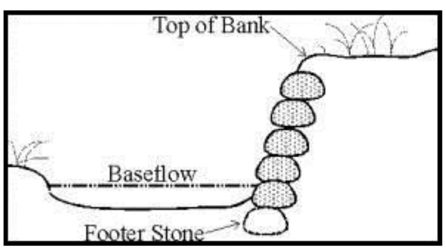
The following presents a list of 20 practices broken down into four major groups: bank protection, grade control, flow deflection/concentration, and bank stabilization.

Bank Protection

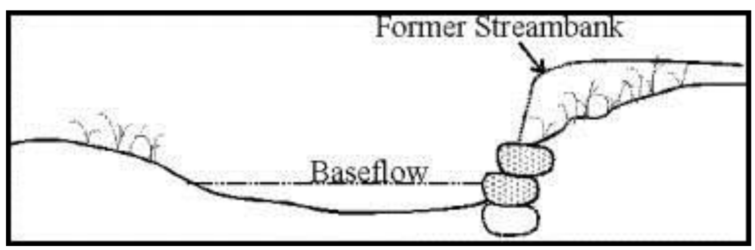
Bank protection practices are designed to protect the streambank from erosion or potential failure. They are typically used along stream reaches where eroding streambanks threaten private property or public infrastructure, or where available space or highly erosive flows are a constraint.

- Root Wad Revetments
- Imbricated Rip-Rap
- Boulder Revetment
- Lunkers
- A-Jacks

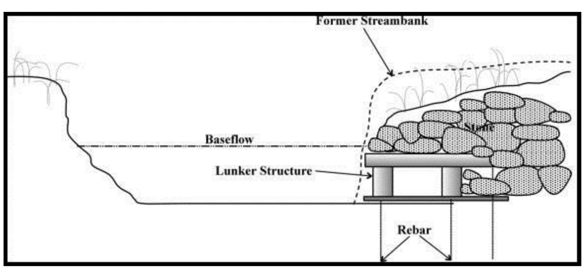
Examples



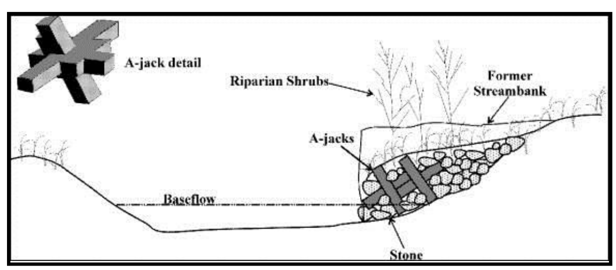
Imbricated Rip-Rap



Boulder Revetment



Lunkers



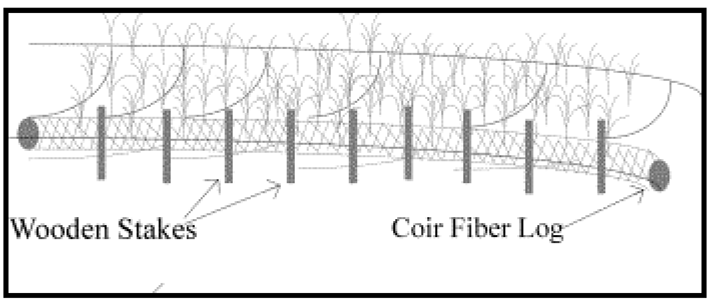
A-Jacks

Bank Stabilization

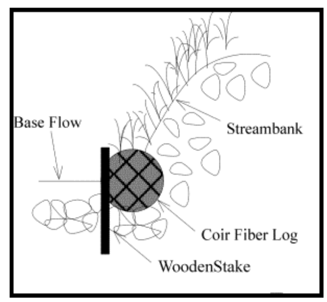
Bank stabilization practices, often referred to as bioengineering, are a nonstructural means of stabilizing streambanks from further accelerated erosion. Bank stabilization practices that rely on vegetation to protect streambanks are much more sensitive to the effects of urbanization than more structural practices. While the effects of increasing imperviousness are less noticeable with structural practices, bank stabilization practices in highly impervious watersheds tended to be less successful. This is the primary reason bank stabilization (e.g., nonstructural) practices are utilized less frequently or used in combination with bank protection practices. While these practices have been found to be very effective on rural and agricultural stream channels (i.e., low impervious cover), they are less able to withstand the elevated storm flows, high stream velocities, and rapid water level fluctuations that occur in urban streams.

- Coir Fiber Rolls
- Live Fascines
- Brush Mattresses
- Erosion Control Matting

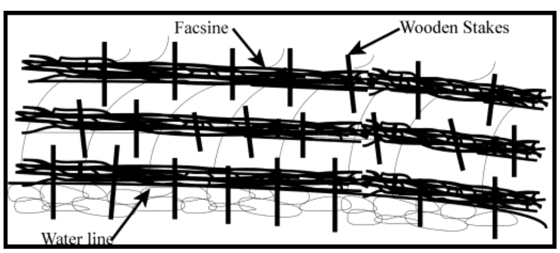
Examples



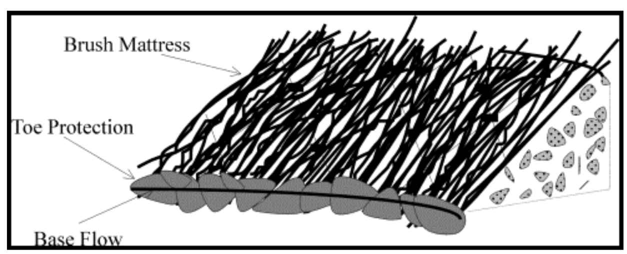
Section View of Coir Fiber Log



Profile View of Coir Fiber Log



Section View of Live Fascine



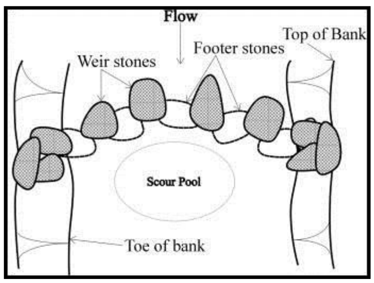
Section View of Brush Mattress

Grade Control

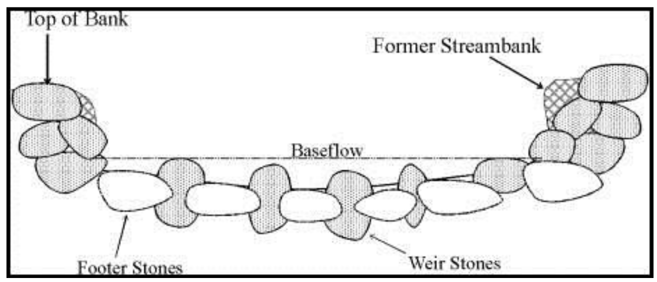
Grade control practices are installed to maintain a desired streambed elevation. These practices are used either to raise the stream invert (i.e., to reverse past channel incision), or to maintain the channel invert at a current elevation (i.e., to prevent channel incision). Nearly all stream restoration projects incorporate some form of grade control practice in the project design. Grade control practices create a “hardpoint” along the channel, preventing the streambed from degrading below the top elevation of the structure. The two main types of grade control practices are those that utilize logs for construction materials and those that utilize rock.

- Rock Vortex Weirs
- Rock Cross Vanes
- Step Vanes
- Log Drops and V-Log Drops

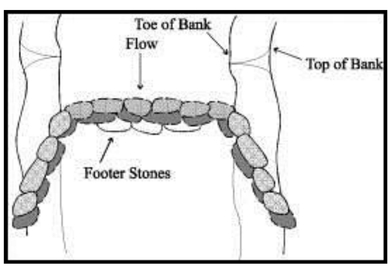
Examples



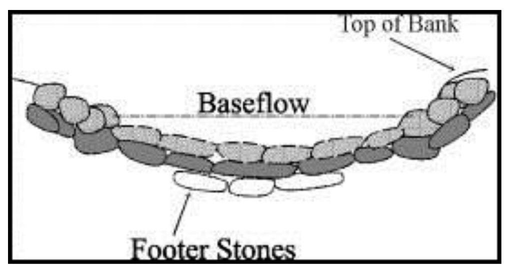
Aerial View of Vortex Weir



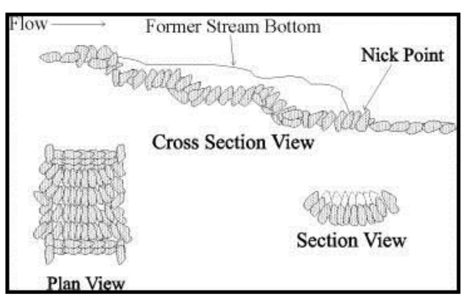
Profile View of Vortex Weir



Aerial View of Cross Vane



Profile View of Cross Vane

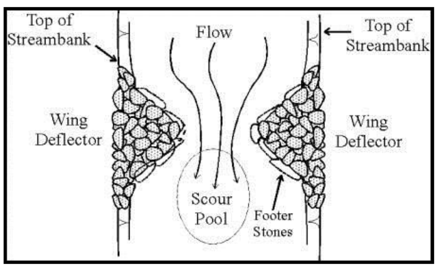


Step Vanes

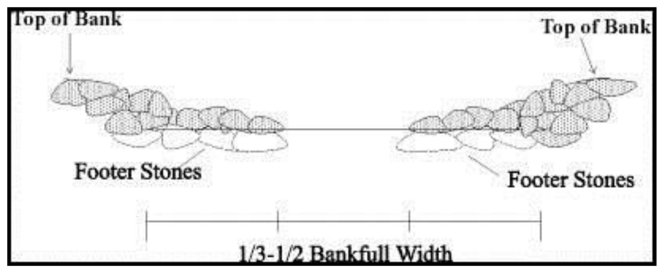
Flow Control

The purpose of flow deflection/concentration practices is to change the direction of stream flow or to concentrate stream flow. These structures are predominately used to deflect flow away from eroding stream banks, concentrate the flow in the center of the channel, redirect water in and out of meanders, and/or enhance pool and riffle habitats.

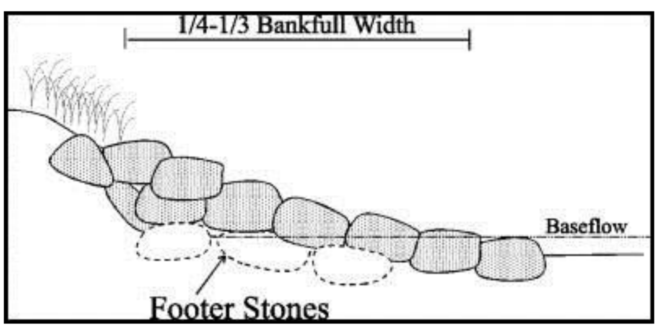
- Wing Deflectors (single)
- Wing Deflectors (double)
- Log, Rock and J-Rock Vanes
- Cut of Sills
- Linear Deflectors



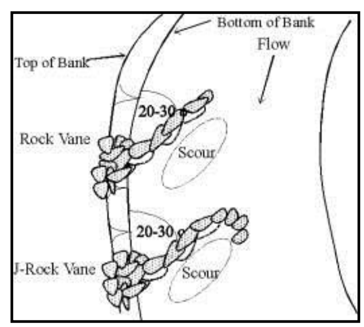
Aerial View of Double Wing Deflectors



Profile View of Double Wing Deflectors



Profile View of Linear Deflectors



Aerial View of Linear Deflectors

TRASH AND DEBRIS DETERRENCE PRACTICES (STRUCTURAL)

Trash and debris originating from urban areas can have a significant impact on local waterways. There are many practices and products that have been designed to deter the impact of trash and debris upon water resources. The following applicable examples will highlight practices which could potentially be employed to protect the health and well being of the Town Branch watershed.

Curb Inlet Screens

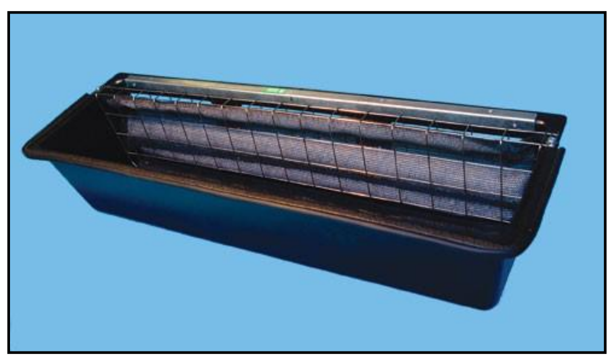
Curb inlet screens are perforated or expanded metal screens that are either designed to fit outside or within the storm drain curb opening. They can be either manual or automatically retractable screens. The proprietary models generally have a filter to capture oil and grease as an optional feature. Regular street cleaning is necessary to keep debris from clogging the face of the screens and to prevent the standing debris from blowing away.

Curb Inlet Screens

Curb Inlet Inserts

Curb inlet inserts are manufactured frames that typically incorporate filters or fabric and placed in a curb opening or drop inlet to remove trash, sediment, or debris. They can also be perforated metal screens placed horizontally or vertically within a catch basin. They are generally capable of catching smaller and larger debris. There are a multitude of inserts of various shapes and configurations, typically falling into one of four different groups: socks, boxes, trays, and screens.

Curb Inlet Box Filter



Curb Inlet Tray Filter

TRASH AND DEBRIS DETERRENCE PRACTICES (NON-STRUCTURAL)

Stream Cleanups and Adoption

Bringing volunteers to streams and waterways was initially considered a public education strategy. Increasingly, however, local government and nonprofit organizations in urban watersheds throughout the State are adopting stretches of streams and cleaning more frequently, such that some programs may be considered cleanup and abatement efforts as well as efforts to promote environmental awareness. Efforts can be facilitated through the Missouri Stream Team Program.

Storm Drain Identification

Identifying storm drains with educational messages through stenciling or markers is an effective and inexpensive way to enlighten the community about littering.

Trash Receptacles

Trash receptacles placed at major intersections, in commercial districts, and other high trash areas provide a relatively inexpensive method for preventing trash from entering the storm drain system. Maintenance labor can be expensive but trash receptacles are easy to maintain and monitor.

Street Sweeping

Street sweeping is an effective urban BMP for reducing trash and total suspended solids from urban streets. It is accomplished using motorized sweeping to sweep streets and municipal parking lots. Street sweeping is well-suited in ultra urban environments where space for structural stormwater controls is limited. It is applicable in commercial business districts, industrial sites, and intensely developed areas near receiving waters.

Stream Cleanup on Town Branch

Storm Drain Marker

Storm Drain with Marker

Trash Receptacle

WATER QUALITY DETENTION PRACTICES

Detention basins are usually located in new residential, commercial and industrial developments, helping control potential flooding. Detention basins require regular maintenance in order to ensure proper function. Poorly maintained basins lose their ability to control flooding and pollution, allowing sediments, fertilizers and pesticides to enter creeks and streams. Homeowners associations and property owners are responsible for maintaining their detention basins

Most detention basins are dry detentions. These are typically dry depressions that temporarily fill with stormwater after a major rain storm. Dry detention basins are less effective at removing pollutants because the stormwater passes through quickly. However, many can be retrofitted to increase pollutant removal efficiency.

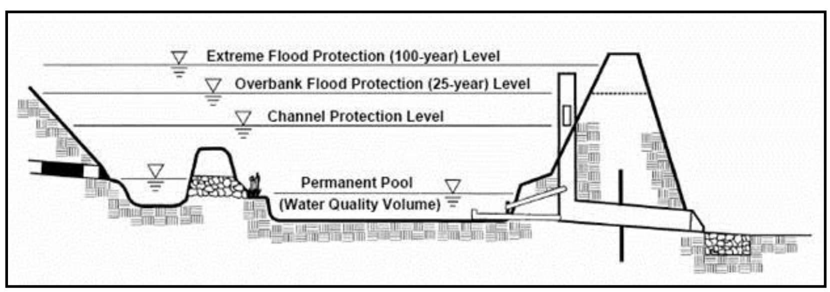
Extended Dry Detention Basin (with Sediment Forebay)

Extended dry detention basins are designed to capture and provide temporary storage for the required water quality capture volume. Extended dry detention basins should be placed outside of the primary watercourses which allow off-site flows to pass through a particular development where possible. It is preferred that a forebay be provided to dissipate energy from incoming flows and to trap sediment entering the basin. The forebay should be separated from the remainder of the basin by an gravel filter dam that slowly releases the stormwater runoff from the forebay into the main detention area, thus allowing sediment to settle out. The outlet of the detention basin should be a vertical perforated riser encased in gravel with an overflow spillway designed for the 100-year flood event. Based on design criteria, the water quality capture volume should be released from 40 to 72 hours.

Extended Wet Detention Basin (with Sediment Forebay)

A wet detention basin has a permanent pool or static level of water. It is designed much like an extended dry detention however is should have enough volume to hold 1 to 1.5 times the amount of captured runoff in order to treat the pollutants in the stormwater. These are very effective in treating pollutants and over an aesthetic benefit for the surrounding properties if so properly maintained.

Extended Dry Detention



Schematic Profile of Extended Dry Detention

6. Water Conservation			
Practice	Financial Assistance	Cooperators	Comments
Education programs for landowners regarding watering practices.	Potential grants	BCWIG, City of Bolivar, NRCS, University Extension	Water conservation in association with lawn care management has become a nationwide issue. The most effective way to promote proper watering is through educational programs.
Emergency Water Conservation Plan	Potential grants	BCWIG, City of Bolivar, Polk County	Due to the potential threat of water quantity shortages, the Missouri Department of Natural Resources encourages communities to have a contingency plan in order to sustain local economic and environmental resources.

Proper Lawn Watering Practices

Lawn grasses and other plants in your landscape need water for growth and development. There is neither sufficient rainfall, nor is it adequately spaced throughout the year in much of North America, to sustain your landscape without supplemental water supplied by irrigation.
Proper watering practices improve the quality of your lawn, provide important environmental benefits, and save you money. It may be hard to believe, but most homeowners tend to over-water their lawns and actually waste water by not following a few relatively simple irrigation practices. This article outlines proper watering practices that will help ensure a healthier lawn.

Lawn Watering Basics

1. The healthiest lawns are produced when they are watered heavily at infrequent intervals. On an average, the lawn needs about one inch of water per week, either by rainfall or in combination with irrigation. This l-inch rule will normally soak the soil to a depth of 4 to 6 inches, allowing the water to reach deep into the root system.

2. The best times to water your lawn are early morning or early evening, when there is generally less wind and heat. Watering then allows for less evaporation into the air, greater penetration into the soil, and less run-off.

3. Let the lawn completely dry out between watering intervals. Most lawn grasses can tolerate dryer conditions over a reasonable period of time. Water only when a probe or screwdriver is difficult to push into the ground or shows that the soil is dry 4 to 6 inches down.

4. Interrupt watering when puddles or run-off occur. Allow water to penetrate into the soil before resuming watering. Soil types vary in the speed at which water will soak into them. Generally speaking, most watering systems apply water faster than it can be absorbed by the soil. Sloping areas are particularly prone to run-off.

5. Keep a newly seeded or sprigged lawn moist, but not soaked, during the germination process. Too much water can cause poor germination and seedling disease. A light mulch over the seed or sprigs will help keep the soil moist. As a new lawn begins to grow, lower the frequency of watering and increase the amount of water. After 4 to 6 weeks, treat the new lawn as an established lawn.

6. If you have a newly sodded lawn, water it thoroughly after placement for about 2 weeks. This allows the root system to become firmly established. Soaking may require watering every day or two. After a couple of weeks, water the sod as an established lawn.

Soil Types Do Make a Difference

Water soaks in at different speeds, depending on the composition of your soil type. If you know your basic soil type, use the following table as a general guide to watering. (Soil test kits and instructions are usually available at lawn and garden centers, and at better hardware stores. Soil test services and information are often available through your local County Extension office).

Soil Type		Infiltration Inch Per Hour	Time For 1 Inch To Soak In
Sand		2.0 inches	0.5 hours
Sandy	Loam	1.0 inches	1.0 hours
Loam		0.5 inches	2.0 hours
Silt	Loam	0.4 inches	2.25 hours
Clay	Loam	0.3 inches	3.3 hours
Clay		0.2 inches	5.0 hours

There are two techniques that will help water absorb into the clay soils more effectively. The first is through the use of a hollow tine core aerator. The aerator is rolled over a lawn, where it inserts metal tines into the soil and removes small cores of grass and soil. The small holes left behind make it easy for water to move down into the soil. They also give grass roots room to grow. A core aerator can be rented for a nominal fee at most equipment rental outlets.

The second technique is to use a chemical called a surfactant, or wetting agent, which reduces the tension surface of the water. This "wetter" water will run more freely into the soil. Apply the surfactant at the manufacturer's recommended rate. Both of these techniques can be used at the same time. They can be very effective on sloping terrain where run-off is a problem.

How to Check Your Watering Rate

No matter what kind of irrigation system or method you use, check and adjust it to the soil's absorption rate. A good rule of thumb is to apply water at a rate equal to or slightly less than the soil ability to absorb it. Most irrigation systems apply water faster than necessary, which wastes water through run-off. Also, don't forget to check if the system is applying water uniformly!

The best way to check both of these functions is to set out a series of straight-side, flat-bottom cans for an in-ground system or a few cans for a movable sprinkler system. Run the watering system for 30 minutes and measure the amount of water collected. You can determine the length of time needed to apply one inch of water with a little simple math. If you know the soil type, check the chart above to figure how long the system needs to run in order to soak the lawn to a desired depth of 4 to 6 inches. Remember to stop the watering for an interval if you see run-off occurring. Hilly or sloping areas may require a soaker hose to reduce run-off and allow better water penetration into the soil. Soakers apply water slowly over a small area.

Quick facts on lawn watering

- Lawns in Missouri may require as much as 1 to 1-1/2 inches of water per week from irrigation or rainfall during summer to remain green and actively growing.
- When managed properly, tall fescue requires 25 percent less water and zoysia grass requires 50 percent less water than Kentucky bluegrass to maintain a green, actively growing lawn in Missouri.
- Turfgrasses in Missouri rank as follows in resistance to leaf wilting and browning during summer dry periods — Bermuda, zoysia, tall fescue, Kentucky bluegrass, perennial ryegrass.
- During extended periods of summer drought, dormant lawns (browned-out leaves) containing Kentucky bluegrass, tall fescue or perennial ryegrass should receive 1-1/2 inches of irrigation every two weeks to maintain hydrated grass crowns and allow for full lawn recovery when more favorable moisture and temperature return in the fall.
- Deeper roots draw moisture from a larger volume of soil and thus require less supplemental irrigation.
- Taller grass has deeper roots and a lower tendency to wilt.
- Taller grass provides shading of the soil surface and reduces lethal temperatures near the base of grass plants.
- Lawns mowed weekly at a taller mowing height are less likely to be scalped. Scalped lawns lose density and have shallow root systems.

Reference: University of Missouri Extension

Drought Management Response Plan

The Missouri Department of Natural Resources encourages local communities to develop a drought management response plan. The following define terms and conditions communities to utilize when addressing such an issue. It is encouraged that communities develop such a plan tailored to their specific needs.

Phases and Classes

There are four phases of severity:

Phase I:	Advisory
Phase II:	Drought Alert
Phase III:	Conservation Phase
Phase IV:	Drought Emergency (Water Rationing)

There are three classes of water use:

Class 1:	Essential Water Uses *Domestic Use, Health Care Facilities, Fire Protection, Electrical Power*
Class 2:	Socially or Economically Important Uses of Water *Agricultural Production, Restaurants, Schools, Churches, Motels Commercial Establishments, Air conditioning, Revegetation Conservation Purposes*
Class 3:	Non-Essential Uses of Water *Outdoor commercial and non-commercial watering, fountains, gardens, lawns, swimming pools, motor vehicle washing and public space watering (parks and golf courses)*

For more information on definitions, classes and how communities can develop such a localized plan; the ***Missouri Drought Plan*** (Water Resources Report 69) should be referenced.

7. Agricultural Land Uses

Practice	Financial Assistance	Cooperators	Comments
Promote agricultural BMPs and cost-share assistance programs.	Federal and state cost-share assistance programs	NRCS, Polk County SWCD	The Natural Resources Conservation Service and the Polk County Soil and Water Conservation District provide technical assistance and cost-share programs to agriculture operators who are looking to improve and sustain the environmental and economic resources of their operations. This would be more applicable for landowners in the Piper Creek watershed since agricultural operations are somewhat limited in the Town Branch watershed.
Promote community urban gardens and farmers markets.	Potential grants	University Extension, NRCS, Polk County SWCD, Community Groups	Locally-led food production initiatives have increased throughout the United States, specifically in urban areas where agriculture production is somewhat limited due to space. Through local groups, the potential for establishing community gardens and private nurseries/orchards to support the Farmer's Market is an option.

AGRICULTURAL PROGRAMS

The Natural Resources Conservation Service (NRCS) and the Polk County Soil and Water Conservation District provide technical assistance and cost-share programs to agriculture operators who are looking to improve and sustain the environmental and economic resources of their operations. This would be more applicable for landowners in the Piper Creek watershed since agricultural operations are somewhat limited in the Town Branch watershed.

The following are examples of different conservation issues/practices that are offered through a variety of federal and state programs in order to improve and sustain the environmental and economic viability of agricultural operations.

- Improved pasture management and forage production
- Proper fencing, grazing and watering design systems
- Nutrient and pest management
- Pond construction and management
- Riparian (streamside) buffer establishment
- Forest stand improvement
- Wildlife habitat

The following is a definition of applicable federal and local programs administered by the NRCS and the Polk County Soil and Water Conservation District:

<u>Environmental Quality Incentives Program</u>

The Environmental Quality Incentives Program (EQIP) is a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of ten years in length. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and for opportunities to improve soil, water, plant, animal, air and related resources on agricultural land and non-industrial private forestland. In addition, a purpose of EQIP is to help producers meet Federal, State, Tribal and local environmental regulations.

<u>Grassland Reserve Program</u>

The Grassland Reserve Program (GRP) is a voluntary conservation program that emphasizes support for working grazing operations, enhancement of plant and animal biodiversity, and protection of grassland under threat of conversion to other uses.

Participants voluntarily limit future development and cropping uses of the land while retaining the right to conduct common grazing practices and operations related to the production of forage and seeding, subject to certain restrictions during nesting seasons of bird species that are in significant decline or are protected under Federal or State law. A grazing management plan is required for participants.

Conservation Reserve Program

The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with Federal, State, and tribal environmental laws, and encourages environmental enhancement. The program is funded through the Commodity Credit Corporation (CCC). CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation.

The Conservation Reserve Program reduces soil erosion, protects the Nation's ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filter strips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is provided to establish the vegetative cover practices.

Conservation Stewardship Program

The Conservation Stewardship Program (CSP) is a voluntary conservation program that encourages producers to address resource concerns in a comprehensive manner by:

- Undertaking additional conservation activities; and
- Improving, maintaining, and managing existing conservation activities.

Emergency Watershed Protection Program

The purpose of the Emergency Watershed Protection (EWP) program is to undertake emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other natural occurrence is causing or has caused a sudden impairment of the watershed.

COMMUNITY GARDENS

Purpose

Community gardens provide fresh produce and plants as well as satisfying labor, neighborhood improvement, sense of community and connection to the environment. They are publicly functioning in terms of ownership, access, and management as well as typically owned in trust by local governments or not for profit associations.

A city's community gardens can be as diverse as its gardeners. Some grow only flowers, others are nurtured communally and their bounty shared, some have individual plots for personal use, while others have raised beds for disabled gardeners.

Community gardens may help alleviate one effect of climate change, which is expected to cause a global decline in agricultural output, making fresh produce increasingly unaffordable. Community gardens encourage an urban community's food security, allowing citizens to grow their own food or for others to donate what they have grown. Advocates say locally grown food decreases a community's reliance on fossil fuels for transport of food from large agricultural areas and reduces a society's overall use of fossil fuels to drive in agricultural machinery.

Community gardens improve users' health through increased fresh vegetable consumption and providing a venue for exercise. The gardens also combat two forms of alienation that plague modern urban life, by bringing urban gardeners closer in touch with the source of their food, and by breaking down isolation by creating a social community. Community gardens provide other social benefits, such as the sharing of food production knowledge with the wider community and safer living spaces. Active communities experience less crime and vandalism.

Examples of Community Gardens

Definition

Unlike public parks, whether community gardens are open to the general public is dependent upon the lease agreements with the management body of the park and the community garden membership.

Open or closed-gate policies vary from garden to garden. There is no 'off the shelf model' of a community garden, however; they provide a green space in urban areas, along with opportunities for social gatherings, beautification, education and recreation.

However, in a key difference, community gardens are managed and maintained with the active participation of the gardeners themselves, rather than tended only by a professional staff. A second difference is food production: Unlike parks, where plantings are ornamental (or more recently ecological), and community gardens often encourage food production by providing gardeners a place to grow vegetables and other crops. To facilitate this, a community garden may be divided into individual plots or tended in a communal fashion, depending on the size and quality of a garden and the members involved.

As discussed below, "community garden" is the term favored in the United States, Canada, Australia and New Zealand. One source and clearinghouse on community gardening information in North America is The American Community Gardening Association, a non-profit membership organization. Research is forming as to whether or not Community Gardening dictates a connotation with social change in the U.S.A. and how changing this term may benefit the effort to involve entire communities.

Community gardens vary widely throughout the world. In North America, community gardens range from familiar "victory garden" areas where people grow small plots of vegetables, to large "greening" projects to preserve natural areas, to tiny street beautification planters on urban street corners. In the UK and the rest of Europe, closely related "allotment gardens" can have dozens of plots, each measuring hundreds of square meters and rented by the same family for generations. In the developing world, commonly held land for small gardens is a familiar part of the landscape, even in urban areas, where they may function as mini-truck farms.

For all their diversity, however, most community gardens share at least four elements in common

In many ways community gardens are re-enforcing basic human instincts that are slowly deteriorating due to the convenience of modern life land (or a place to grow something)

- land
- plantings
- gardeners
- some sort of organizing arrangements

Appendix C

EPA's 9 Key Elements Critical to a Watershed Management Plan

EPA's 9 Key Elements Critical to a Watershed Management Plan

A. *Identify causes and sources of pollution that need to be controlled.*

Definition: An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).

B. *Determine load reductions needed.*

Definition: An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks).

C. *Develop management measures to achieve goals.*

Definition: A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

D. *Identify Technical and financial assistance needed to implement the plan.*

Definition: An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs,
State Revolving Funds, USDA‟s Environmental Quality Incentives Program and
Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.

E. *Develop information/education component.*

Definition: An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

F. *Develop an implementation schedule.*

Definition: A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.

G. *Develop interim milestones to track implementation and management measures.*

Definition: A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

H. *Develop criteria to measure progress toward meeting watershed goals.*

Definition: A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised.

I. *Develop monitoring component.*

Definition: A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Appendix D

Glossary of Terms

Terms and Definitions

Algae - aquatic organisms, ranging in size from single-celled forms to the giant kelp

Ammonia - ($NH3$) an inorganic nitrogen compound. In water, ammonia levels in excess of the recommended limits may harm aquatic life.

Baseflow - the portion of streamflow derived from groundwater flowing into a stream or river; that flow which is not affected by surface runoff.

Basin – See Watershed

Best Management Practices (BMP) –reasonable and cost-effective means to reduce the likelihood of pollutants entering a water body. BMPs include riparian buffer strips, bioswales, nutrient management plans, rain gardens, pervious concrete, etc.

Bioswale – A bioswale is a shallow depression created in the earth to accept and convey storm water runoff. A bioswale uses natural means, including vegetation and soil, to treat storm water by filtering out contaminants being conveyed in the water.

Clean Water Act (CWA) - is commonly used to describe the series of legislative acts that form the foundation for protection of the nation's water resources. Sections of the CWA address different types of water pollution in different ways. *Section 305b* and *Section 303d* of the CWA deal specifically with water quality assessment and TMDL development.

E. coli (Escherichia coli) - a subgroup of fecal coliform bacteria that are present in the intestinal tracts and feces of warm-blooded animals. E. coli are used as an indicator of the potential presence of pathogens.

Effluent - (1) Something that flows out forth (2) Discharged wastewater such as the treated wastes from animal production facilities, industrial facilities, or wastewater treatment plants.

Erosion - the detachment and transport of soil particles by water and wind. Sediment resulting from soil erosion represents the single largest source of nonpoint source pollution in the United States.

Eutrophication - the process of enrichment of water bodies by nutrients. Eutrophication is normally a slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. Waters receiving excessive nutrients may become prematurely eutrophic, are often undesirable for recreation, and may not support normal fish populations.

Failing septic system - septic systems in which the drain field has failed such that effluent (wastewater) that is supposed to percolate into the soil, rises to the surface and ponds on the surface where it can run into streams or rivers and pollute them.

Hydrology - the study of the distribution, properties, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Impaired waters - those waters with chronic or recurring monitored violations of the applicable numeric and/or narrative water quality standards.

Karst - A terrain, generally underlain by limestone or dolomite, in which the topography is chiefly formed by the dissolving of rock and which may be characterized by sinkholes, sinking streams, closed depressions, subterranean drainage, and caves.

Losing Stream - a stream in which a section of the stream is losing water into the subsurface material.

Low Impact Development (LID) – a stormwater management approach with a basic principle that is modeled after nature: manage rainfall at the source using uniformly distributed decentralized micro-scale controls. LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. (http://www.lid-stormwater.net/background.htm)

Monitoring - periodic or continuous sampling and measurement to determine the physical, chemical, and biological status of a particular media like air, soil, or water.

Nitrate (NO3-) an inorganic nitrogen compound. Nitrate may be naturally present in water, but high concentrations (greater than 2 or 3 ppm) are most likely due to fertilizer runoff, livestock facilities, sanitary wastewater discharges, and/or atmospheric deposition (nitrate dissolved in precipitation). High levels of nitrate in drinking water (greater than 10 mg/l) are associated with methemoglobinemia and possibly an increased risk for some cancers.

Nitrogen - an essential nutrient to the growth of organisms. However, excessive amounts of nitrogen in water can contribute to abnormally high growth of algae reducing light and oxygen in aquatic ecosystems.

Nonpoint source (NPS) pollution - pollution originating from diffuse sources on and above the landscape. Examples include runoff from fields, stormwater runoff from urban landscapes, roadbed erosion in forestry, and atmospheric deposition.

Nutrient - (1) an element or compound essential to life, including carbon, oxygen, nitrogen, phosphorus, and many others; (2) as a pollutant, any element or compound, such as phosphorus or nitrogen that in excessive amounts contributes to abnormally high growth of algae reducing light and oxygen in aquatic ecosystems.

Perennial - Lasting or active through the year or through many years.

Phosphorus - an essential nutrient to the growth of organisms. However, excessive amounts of phosphorous in water can contribute to abnormally high growth of algae reducing light and oxygen in aquatic ecosystems.

Point source pollution - pollutant loads discharged at a specific location. Point source discharges are generally regulated through the National Pollution Discharge Elimination System (NPDES) permitting procedures. Point sources can also include pollutant loads contributed by tributaries to the main receiving stream or river. During TMDL development, permitted point sources are assigned a waste load allocation for the pollutant in question.

Rain Barrel – Any container designed to collect rain from a rooftop or other surface to be used at a later time.

Rain Garden – a shallow depression planted with native plants designed to intercept and infiltrate stormwater.

Riparian - pertaining to the banks of a river, stream, pond, lake, etc., as well as to the plant and animal communities along such bodies of water.

Runoff - that part of rainfall or snowmelt that does not infiltrate but flows over the land surface, eventually making its way to a stream, river, lake or an ocean. It can carry pollutants into receiving waters.

Stakeholder - Stakeholders are the specific people or groups who have a stake, or an interest, in the outcome of the project.

Section 303(d) - section of the Clean Water Act that requires states to periodically identify waters that do not or are not expected to meet applicable water quality standards. These waters are identified on the 303(d) Impaired Waters List. A TMDL must be developed for each water on the 303(d) list. If a listed water has multiple impairments (multiple reasons for degraded water quality), a TMDL must be developed for each impairment.

Sediment - in the context of water quality, soil particles, sand, and minerals dislodged from the land and deposited into aquatic systems as a result of erosion.

Septic system - an on-site system designed to treat and dispose of domestic sewage. A typical septic system consists of a tank that receives waste from a residence or business and a drain field or subsurface absorption system consisting of a series of percolation lines for the disposal of the liquid effluent. Solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically.

Sinkholes – a saucer-shaped surface depression produced when underlying material, such as limestone or salt, dissolves or when caves, mines, etc. collapse.

Soil Series - A family of soils having similar profiles, and developing from similar original materials under the influence of similar climate and vegetation.

Total Maximum Daily Load (TMDL) - pollution "budget" that is used to determine the maximum amount of pollution a water body can assimilate without violating water quality standards. The TMDL includes pollution from permitted point sources (Waste Load Allocations, WLAs), and nonpoint and natural background sources (Load Allocations, LAs). In addition to the load allocations, the TMDL includes a margin of safety (MOS). The MOS accounts for any uncertainty associated with estimating the load allocations. Mathematically, a TMDL is written as follows: TMDL = LC = WLAs + LAs + MOS
A TMDL is developed for a specific pollutant and can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to the water quality standard being violated.

Tributary - a lower order-stream compared to a receiving waterbody. A tributary will be upstream from, and flow into, the receiving waterbody, i.e. the Missouri is a tributary to the Mississippi.

Wastewater treatment - chemical, biological, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants. Treatment facilities are often referred to by the acronyms STP (sewage treatment plant) or POTW (publicly owned treatment works) or WWTP (waste water treatment plants).

Water quality - the biological, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.

Watershed - area that drains to, or contributes water to, a particular point, stream, river, lake or ocean. Larger watersheds are also referred to as basins. Watersheds range in size from a few acres for a small stream, to large areas of the country like the Chesapeake Bay Basin that includes parts of six states.